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Job Performance Report
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Subproject II, Study IV

Job 1. Rapid River Bull Trout Movement and Mortality Studies
Job 2A. Bull Trout Aging Studies
Job 2B. Angler Exploitation of Rapid River Bull Trout and Incidental Harvest of Bull Trout by Steelhead Trout Anglers

By:

Steve Elle, Senior Fishery Research Biologist
Idaho Department of Fish and Game, Nampa, Idaho
Russ Thurow, Research Scientist
USFS Intermountain Research Station, Boise, Idaho
Tony Lamansky, Fishery Technician
Idaho Department of Fish and Game, Nampa, Idaho

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JOB PERFORMANCE REPORT

State of: **Idaho**

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Title: **Rapid River Bull Trout Movement, and Mortality Studies**

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ABSTRACT

During 1993, 149 bull trout *Salvelinus confluentes*, were collected in the Rapid River upstream trap. Upstream migration appeared to coincide with temperatures Z10°C.and falling hydrograph following peak runoff. We surgically implanted 32 bull trout with radio tags during 1993. Four of six spawners radio tagged in 1992, that we monitored during winter 1992-93, returned to spawn in 1993.

We could detect no major changes in spawning sites selected by the fish tagged on three different dates in 1993. Thirty-one percent of the radio tagged bull trout <450 mm, total length, did not migrate upstream to the spawning areas. We believe these fish are subadults which migrate out of the Salmon River but do not spawn. Fall outmigration of bull trout occurred in late September and October during 1993. Peak trap counts occurred as temperatures dropped below 10°C. Downstream trap counts indicated 53% and 79% of the tagged and untagged bull trout >300 mm survived through spawning to outmigration, respectively. Our study design has limitations, however, and these differences may not be as large as the numbers indicate. Bull trout overwintered primarily in the Salmon River from Riggins downstream to Whitebird, similar to 1992. One fish moved downstream 114 km to Maloney Creek.

Authors:

Steven Elle
Senior Fishery Research Biologist
Idaho Department of Fish and Game
Nampa, Idaho

Russ Thurow
Research Scientist
USFS Intermountain Research Station
Boise, Idaho

INTRODUCTION

Bull trout Salvelinus confluentus were petitioned for listing under the Endangered Species Act (ESA) in 1992. With the petition for listing has come increased emphasis on collecting life history and stock status information by land and population management agencies. Bull trout behavior and life history patterns make detailed studies difficult (Schill et al. 1994). Low population densities of bull trout (Schill 1992) add to the difficulty of population studies.

The use of radio telemetry can greatly improve our ability to obtain life history information. During 1992, a study was initiated on bull trout life history in the Rapid River drainage (Schill et al. 1994). They used surgically implanted radio tags to track spawning movements and locations of Rapid River fish and subsequent overwinter distribution in the Salmon River. Tagged bull trout spawned in four principal reaches, all in the 10 uppermost kilometers of the drainage.

Spawning mortality appeared quite heavy during 1992 (67%). Post-operative survival for bull trout was 100% for 2-3 months after surgery. Following spawning, however, only 10 of 30 radio tagged fish outmigrated to the Salmon River where overwintering occurs. The authors could not determine if estimated survival (33%) was effected by tag shedding which has been reported for other species (Summerfelt and Mosier 1984; Chisholm and Hubert 1985; Tyus 1988; Helm and Tyus 1992).

It is also possible that the radio tags added to natural mortality factors. If the use of radio implants results in elevated mortalities of adult fish, the trade-offs of increased life history knowledge versus impacts to populations may not be acceptable, especially in very small populations (Schill et al. 1994).

During 1992, Idaho was in the fifth year of a continuing drought. Flows reached all time low discharges for recorded history. Radio tracking bull trout provided valuable information on the timing and location of spawning areas in Rapid River. Bull trout did not spawn in some of the tributaries and headwater areas where suitable spawning substrate exists, however.

During 1993, we continued radio telemetry studies at Rapid River (Schill et al. 1994) to estimate survival of bull trout spawners in the drainage. We tested differential mortality between radio tagged and untagged bull trout 380 mm and larger. We also utilized the second season of tagging to determine if bull trout would utilize similar or different spawning times and locations with increased discharges present during 1993. Detailed results of this effort will be presented in a companion U.S. Forest Service report.

While several studies have addressed adult bull trout movement (Schill et al. 1994; Bjornn and Mallet 1964), little is known about migration patterns of juvenile bull trout in Idaho. Russ Kiefer (Idaho Department of Fish and Game, personal communication) and Rob Keith (Shoshone-Bannock Tribes fishery biologist, personal communication) have noted some downstream movement in the fall incidental to anadromous fish trapping studies in Salmon and Clearwater rivers' tributaries. Riehle and Weber (In press) documented large juvenile bull trout emigrations in Jacks Creek of the Metolius River system in Oregon. Their trapping records indicate most bull trout emigrate in the April-June period compared to September-October. Knowledge of outmigrant timing and fish size for fluvial bull trout from natal tributaries to mainstem rearing areas is important in understanding threats to the species. These information and survival estimates of outmigrating juveniles to spawning age will help us evaluate impacts from various management actions.

OBJECTIVES

Research Goal: Provide sufficient life history data to maintain and restore bull trout for trophy fishing opportunities.

1. To document timing and size of juvenile bull trout emigrants and begin survival estimates.
2. To assess winter movement patterns and habitat used by adult bull trout in Salmon River.
3. To estimate spawning mortality of bull trout in Rapid River.
4. To determine the effects of surgically implanted radio tags on bull trout survival during spawning.

METHODS

Rapid River is a fourth order tributary to the Little Salmon River near Riggins, Idaho (Figure 1). The study area is described in detail in Schill et al. (1994).

Adult Migration and Taaaina

Rapid River Fish Hatchery personnel collected all upstream migrant bull trout at the adult chinook _Oncorhynchus_ _tschawytscha_ trap. The trap is adjacent to an upstream migration velocity barrier. All fish migrating upstream must pass through the trap. All bull trout were inspected for evidence of radio or floy tagging from 1992 and total length was measured to the nearest millimeter. We trapped three repeat spawners from 1992 tagging studies. All repeat spawners and a subsample of the fish captured for the first time were held at the hatchery for implantation of radio tags (32 fish). The remaining bull trout were measured and released into Rapid River upstream of the hatchery.

We tagged fish over a broader portion of the run than in 1992 to determine if migration timing affected the location or timing of spawning. We tagged 11

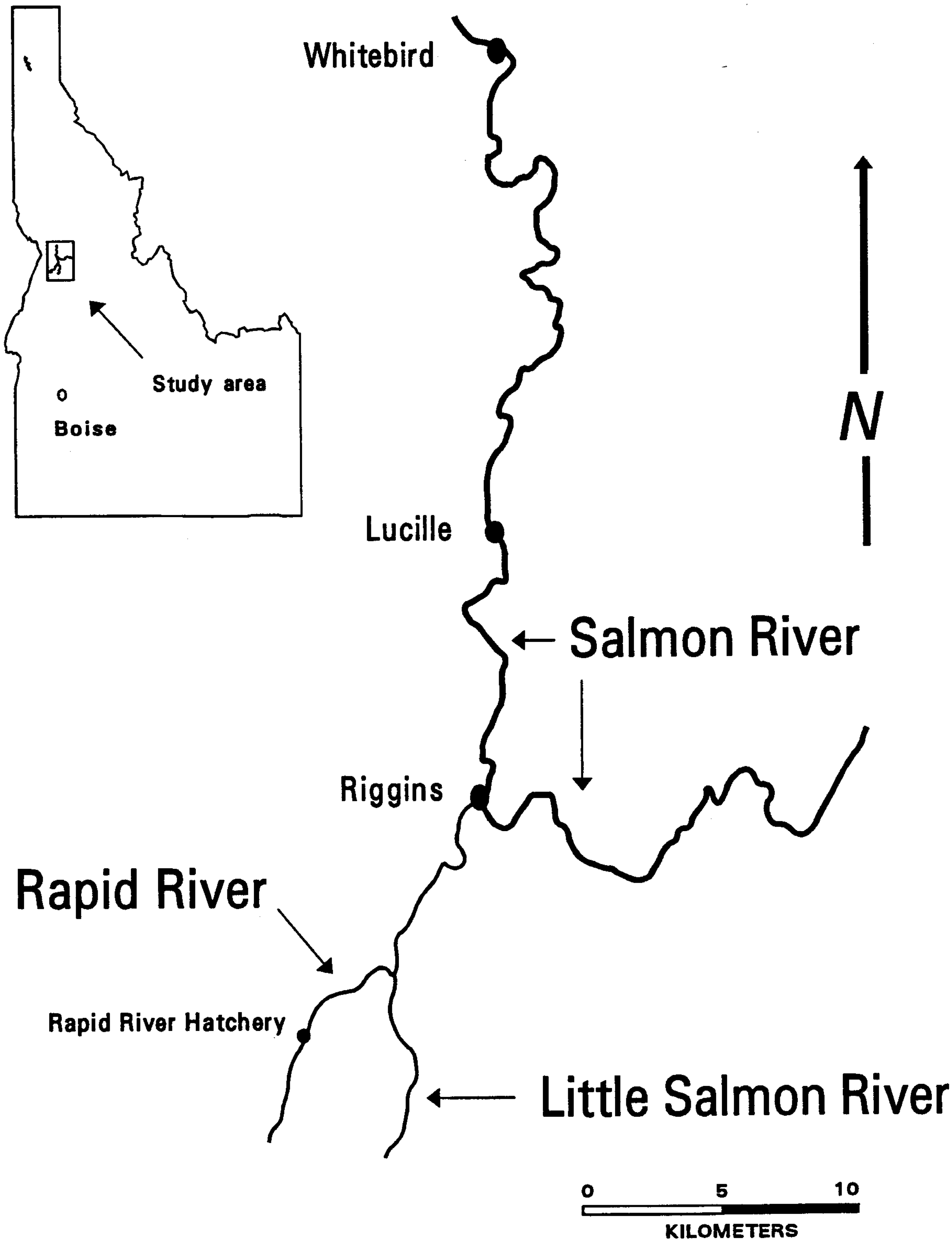

Figure 1. Study area for the Rapid River bull trout radio telemetry study.

bull trout on June 16-18 and 10 fish each on June 28-29 and July 6-8. A repeat spawner from the 1992 tagging study was retagged on July 21.

Handling of bull trout prior to and during surgery is described in Schill et al. (1994). Radio tags and receivers were purchased from Advanced Telemetry Systems,"Inc. (ATS), Insanti Minnesota. Unique individual frequencies ranged form 150.015 to 150.685 MHZ. Tags weighed 6, 10, and 20 g. Marty and Summerfelt (1986) suggested limiting transmitter weights to less than 2% of the fish's weight. We weighed all bull trout considered for tagging and limited the ratio of tag weight to fish body weight to 1.3%. No fish less than 380 mm were tagged.

Sex ratio of the Rapid River bull trout run is unknown. We sexed bull trout selected for radio tagging based on external characteristics including head and jaw shapes, size of the adipose fin, and coloration of anal fin. During surgery, prior to radio tag implantation, we used a veterinary Popper otoscope with a 80 mm ear speculum to verify our external estimate of sex. Following surgery we floy tagged fish to monitor radio tag expulsion and provide a visual tag for a companion angler exploitation study.

Downstream Trapping

We constructed a picket-style weir at Rapid River Fish Hatchery to monitor downstream migrant salmonids. We erected the weir on August 3 and operated it through October 22. The weir design consisted of a single wing, (23.5 m long), angled downstream to a 0.17 m (6 in) diameter intake pipe leading to a trap box constructed of perforated metal. The trap box dimensions equalled 1.22 m x 0.6 m x 0.76 m with a solid front face to provide calm water for captured fish. The pickets were 1.7 cm in diameter and spaced 1.3 cm apart. The weir was designed to capture all fish over 300 mm and subsample smaller salmonids.

Biological data was recorded for all fish collected in the downstream trap. All fish collected were anesthetized using MS 222, identified, measured to the nearest millimeter (total length for bull trout and fork length for chinook salmon *Oncorhynchus tshawytscha* and steelhead trout *Oncorhynchus, mykiss),* and weighed to the nearest gram. In an effort to determine if bull trout can shed radio tags and survive, we examined all outmigrant bull trout >300 mm for loss of radio tags. If bull trout shed tags, we expected at least some would survive and have one of the following characteristics: 1) a floy tag, 2) a surgical incision or antennae exit scar, or 3) a scar where the floy tag had been lost. We Passive Integrated Transponder (PIT) tagged (Pacific Management Fisheries Council 1994) a portion of outmigrating juvenile bull trout 5300 mm and all adult bull trout (>300 mm). Survival of these individuals will be assessed by interrogating all bull trout in future Rapid River runs with Pit tag detectors.

Tagged versus Untagged Comparisons

We calculated mean condition factor (K = W/L') for radio tagged, floy tagged, and untagged bull trout captured in the downstream trap (Busacker et al. 1990). Condition factor was calculated for fish >--380 mm. Calculated values were multiplied by 10^5 for reporting purposes. We used a t-test to test differences in condition factors of tagged versus untagged fish (Zar 1984).

We calculated the survival of bull trout x300 mm to the period following spawning when the fish migrate downstream to the Salmon River to overwinter. We defined this survival to outmigration; its complement is spawning mortality. During 1992 and 1993, a portion of the radio tagged bull trout 380-449 mm in length did not migrate to spawning areas in the headwaters of Rapid River. Based on behavior we consider these fish to be subadults. During 1993, 4 of 13 (31%) radio tagged fish in this size group migrated downstream of Rapid River Fish Hatchery prior to the period of trap installation in early August. All of these fish survived to at least late September, when most bull trout had spawned and completed their outmigration. We assumed behavior of small (<449 mm), untagged bull trout was similar and adjusted the number captured in our downstream trap upward by 31%. We used a chi-square test (Zar 1984) to compare outmigration survival of tagged and untagged bull trout to the downstream weir. We then used the Yates correction for a 2 x 2 contingency table.

Overwinter Tracking

We conducted ground tracking of 14 radio tagged bull trout which migrated out of Rapid River into the Little Salmon and Salmon rivers to monitor general winter movement patterns. We completed eight ground surveys from October 10, 1993 through March 29, 1994. Aerial surveys on October 21, 1993 and January 28, 1994 were used to locate fish missing from ground surveys. We categorized the habitat types utilized by fish at all locations as pools, runs, or riffles (Sisson et al. 1982). We recorded fish locations in relation to landmarks and highway mile markers to determine movement from prior surveys.

RESULTS

Adult Migration and Tagging

A total of 149 bull trout were captured during the 1993 spawning migration. The total lies within the range observed over the past 20 years but is just over half the fish collected the past 3 years (Figure 2). The first fish were trapped May 12, and upstream migration continued through August 17 (Figure 3). The run peaked on June 29 with few fish entering the trap after August 4.

Upstream migration may be related to water temperature and flows. Following a few sparse initial captures, the trap counts dropped to zero for 3 weeks.

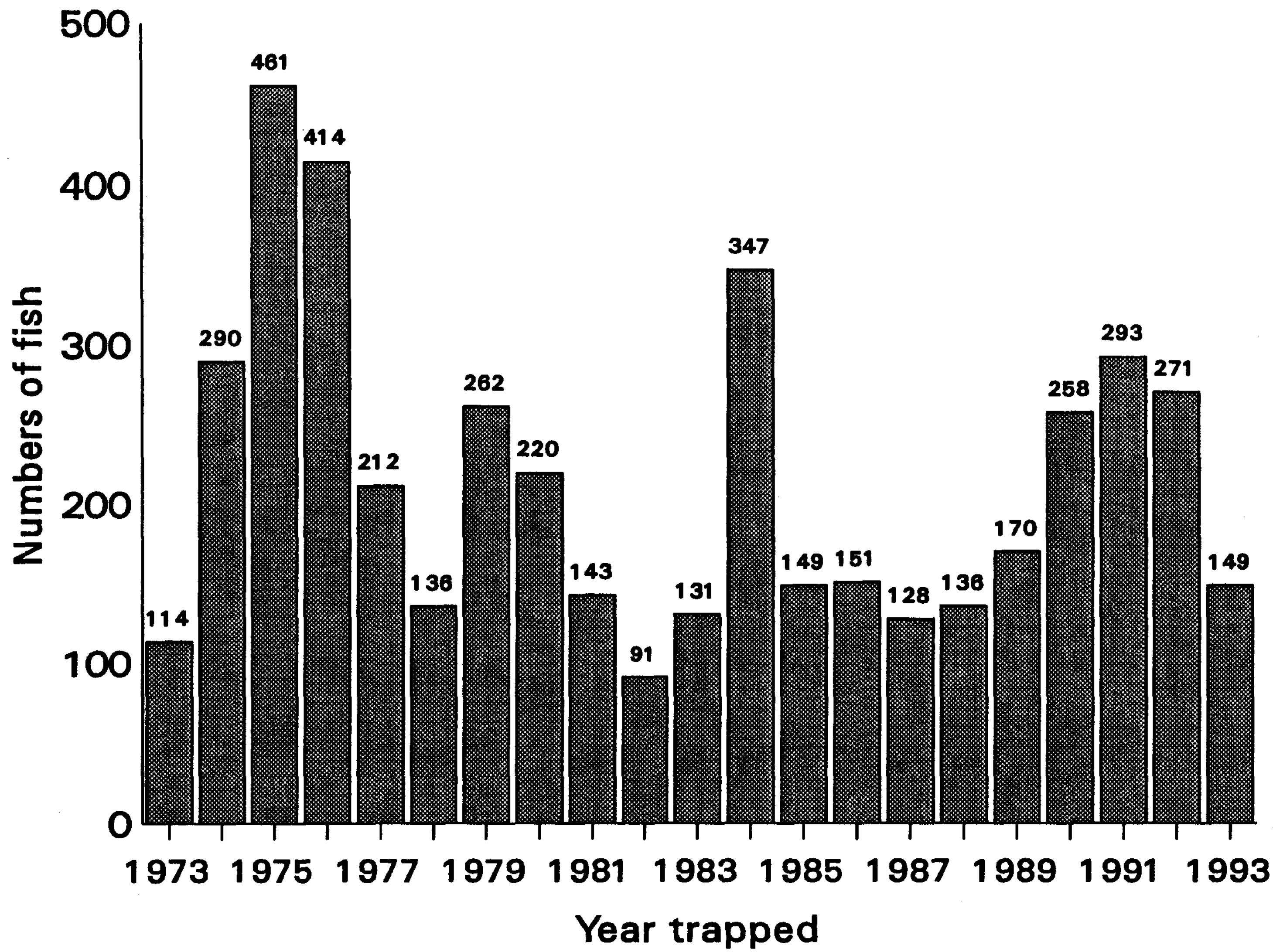

Figure 2. Numbers of adult bull trout moving upstream past the Rapid River weir, 1973-1993.

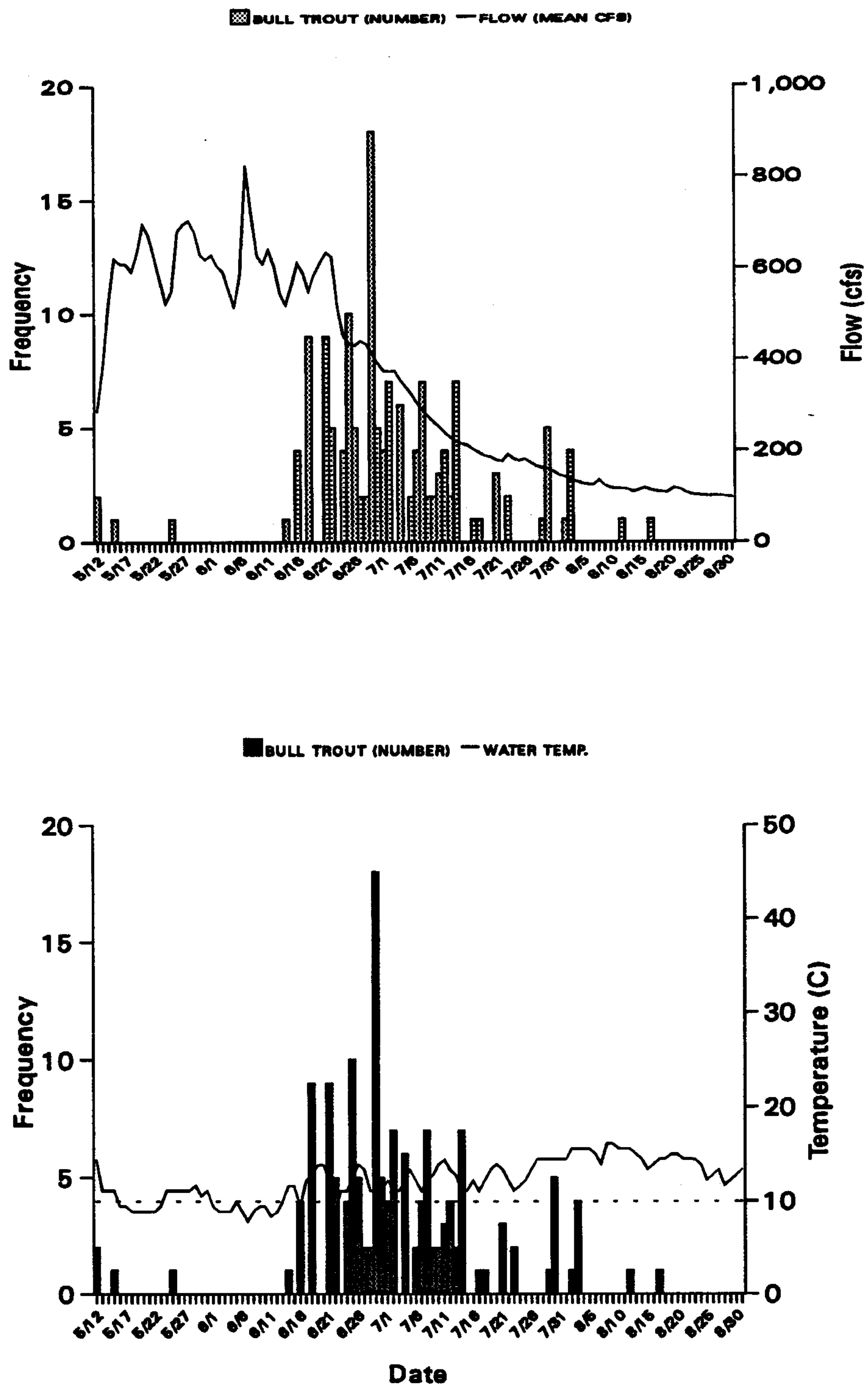

Figure 3. Trap counts of bull trout moving upstream past the Rapid River weir for 1993 with discharge and temperature data during trapping period.

This period coincided with decreasing water temperatures and a rising hydrograph (Figure 3). Upstream migration resumed with a declining hydrograph and water temperatures rising to or above 10°C. Temperatures of 10°C. occurred briefly in May and again in June when fish were moving into the trap. Due to high water and sediment loading, the trap was closed from May 16-23, June 1-4, and June 7-9. The velocity barrier prevented any bull trout from passing upstream during periods of trap closure. Water temperatures were less than 10°C during this period and fish did not immediately enter following the trap reopenings.

Four of six bull trout we tracked during the winter of 1992-93 from the 1992 spawning season returned to spawn during 1993. We suspect one of the two non-returning fish was an unreported angler harvest. Thus, the rate of repeat spawning was 66-80% depending on the number of fish alive at time of upstream migration. One of the repeat spawners was harvested in the tribal fishery in Rapid River and no information other than tag number was recovered.

Upstream migrating bull trout ranged in size from 180 to 600 mm and averaged 406 mm. The 1993 sample of radio tagged fish under-represented smaller bull trout in the adult migration (Figure 4). Radio tag weights averaged 0.96% (range 0.5-1.3%) of the total fish weight in the 32 fish tagged (Appendix A).

We lacked confidence in our ability to accurately sex bull trout either by external characteristics or by internal inspection with the otoscope. With the fish 1-3 months from spawning, the external sexual dimorphisms were not clearly developed. The presence of pyloric caeca and fat tissue in the body cavity of bull trout made internal identification of the sex organs difficult, especially on males. The speculum on the otoscope was 80 mm long. Looking through the end of the speculum made identification of organs difficult without physically moving them with a probe. Probing too close to the kidney to find sex organs with the speculum or a separate probe could result in injury. We discontinued use of the otoscope for sex determinations after the second surgery period.

Downstream Trapping

Downstream migration of juvenile bull trout began in early September and continued sporadically through October 20 (Figure 5). Peak numbers of fish were collected September 22-23 when daytime high water temperatures declined below 10°C. Bull trout adult and juvenile timing at the weir were similar with the first adults trapped September 21 (Figure 5). We observed adult and juvenile bull trout staging above the hatchery intake dam and our trap prior to September 14. The peak entry into our trap facilities coincided with a temperature drop of 4-5°C.

We trapped a total of 323 bull trout in the downstream weir ranging in length from 157 to 532 mm (Figure 6). We believe fish <300 mm were juveniles and primarily age 2+ and 3+ (see Job 2A). We tagged 302 of the bull trout with PIT tags. Since all adult bull trout migrating up Rapid River are captured at the velocity barrier, future detections of PIT tagged juveniles will be used to estimate survival of rearing fish in the mainstem Salmon River. A record of Floy and PIT tag data is provided in Appendix B.

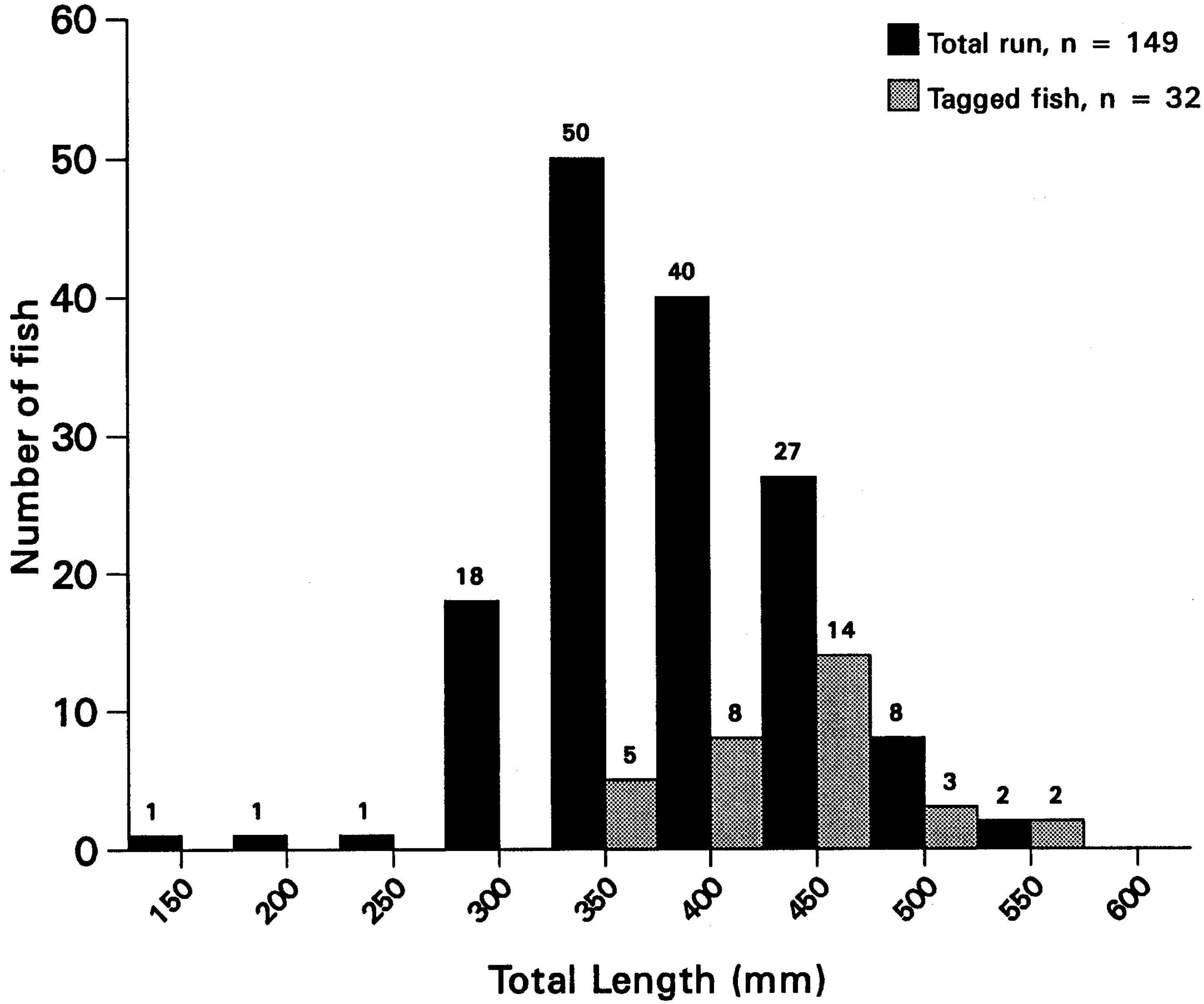

Figure 4. Length frequency of bull trout migrants and radio tagged fish migrating upstream past the Rapid River weir, 1993.

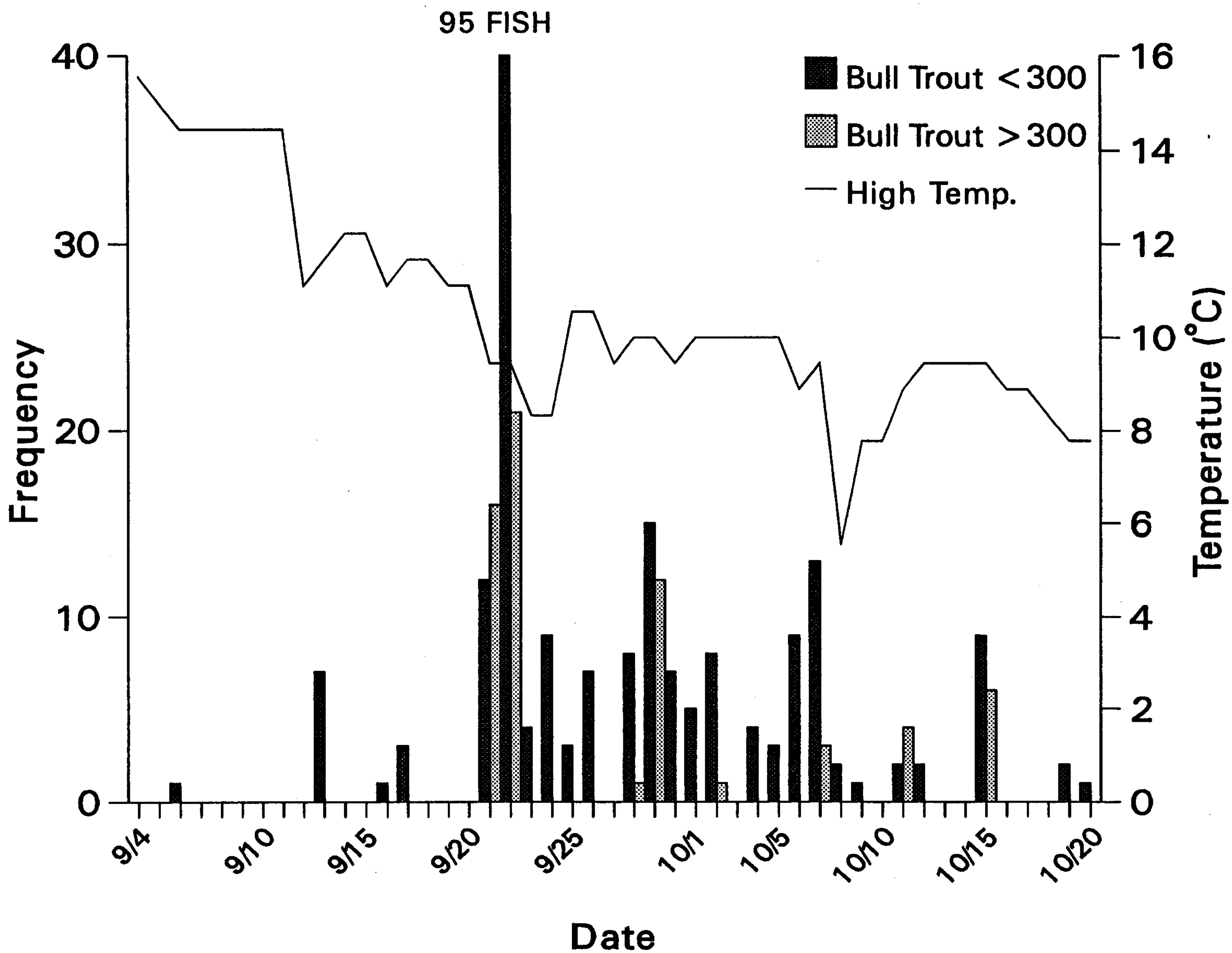

Figure 5. Timing of adult and juvenile bull trout downstream migration in Rapid River during fall 1993 and daytime high water temperature data during trapping period.

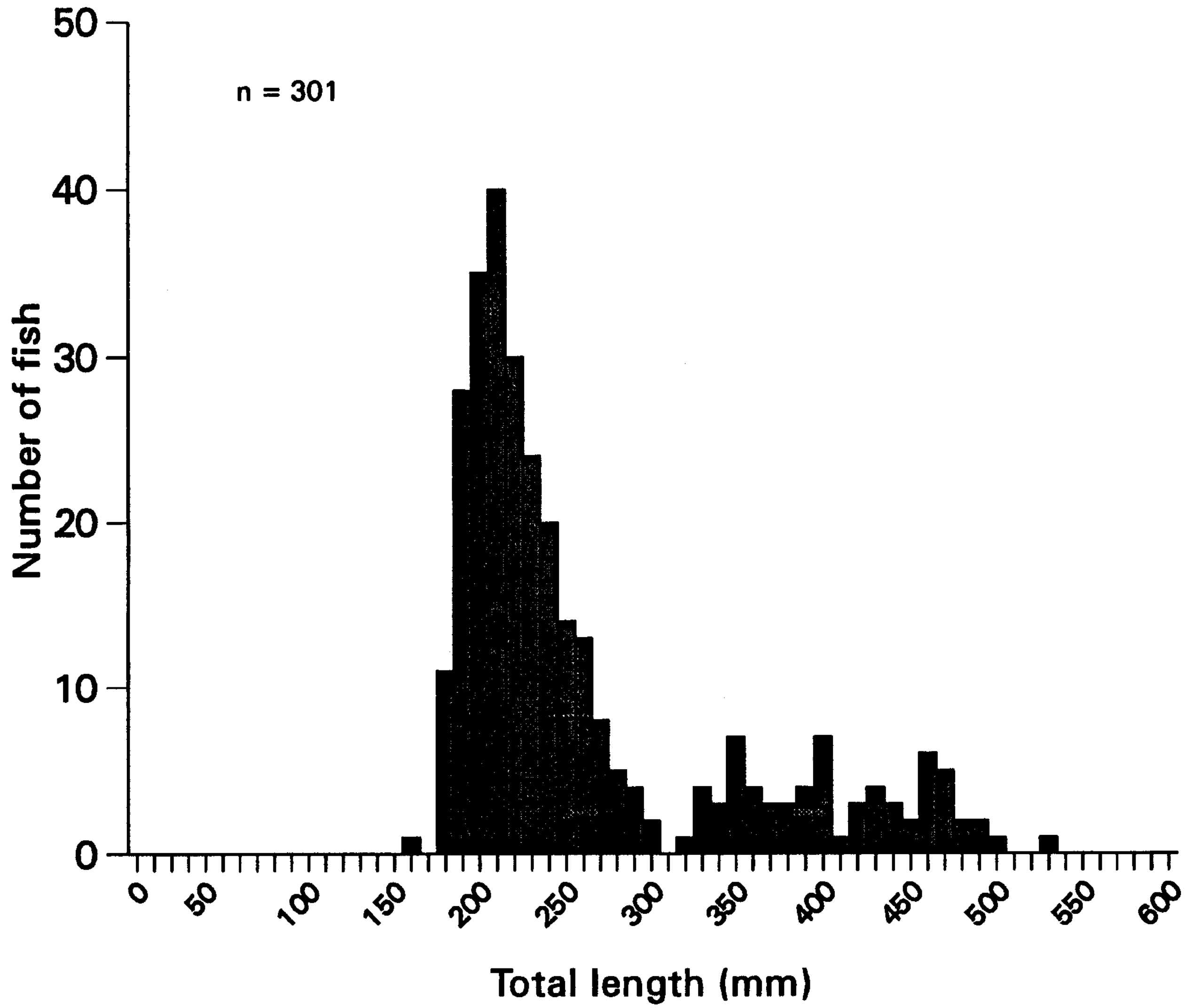

Figure 6. Length frequency distribution for bull trout migrating downstream in Rapid River, fall 1993.

Trap efficiency calculated for the entire trapping period for bull trout <300 mm equalled 51.8%. The estimated number of bull trout outmigrants <300 mm for August 4 through October 20 was 542 fish. We did not calculate confidence intervals due to highly variable trap efficiencies, however, and this estimate should be viewed with caution.

In addition to bull trout, we captured 376 steelhead trout parr, 6 chinook salmon parr, and 1 westslope cutthroat trout Oncorhynchus clarki lewisi. We PIT tagged 288 steelhead trout parr for other Idaho Department of Fish and Game researchers. Outmigrant timing of steelhead trout parr coincided with bull trout.

Tagged versus Ontagged Comparisons

Based on fish trapped at the downstream weir, radio tagged bull trout had lower survival rates compared to untagged bull trout (Table 1). We estimated 53.1% survival (17 of 32 fish) for all size classes of radio tagged bull trout. Survival ranged from 69.2% for the 380-449 mm length group to 42.1% for the 450 mm and larger group. Based solely on trap captures, untagged bull trout survived at an overall rate of 83.5%. At least five fish we trapped as outmigrants could not possibly have been part of the upstream count, however (Figure 7). They were smaller (300-319 mm) than fish moving upstream. We made a crucial error in not marking untagged upstream migrants. A corrected estimate of untagged survival excluding these five fish is 79.1% (Figure 8). It is possible that other fish in the untagged group are positively biasing the estimate of untagged survival. Nonetheless, there was no significant difference between the radio tagged and the untagged bull trout survival to outmigration ($P < 0.05$).

Condition factors for bull trout with radio tags were lower than untagged fish {Table 1). We calculated a mean condition factor of 0.739 for radio tagged fish ($n = 12$) and 0.782 ($n = 59$) for untagged fish. The difference between the means was not significant ($P < 0.05$).

During 1993, only 17 of 32 radio tagged bull trout outmigrated from Rapid River following the spawning period in September and October. As in 1992, a high percentage of the tags were retrieved from the stream corridor, generally downstream of the spawning location.

We did not observe any bull trout which had shed their radio tag and survived to capture at the downstream trap. Although most of the surgical scars were well healed, they were readily visible. All fish which we had radio tagged either retained the tag or did not survive to outmigration.

Overwinter Behavior

Of the 32 tagged bull trout, we believe 17 survived to reach the Little Salmon or main Salmon rivers. Anglers harvested two tagged bull trout in the

Table 1. Survival and condition factor comparisons for radio and floy tagged (1_380 mm) versus untagged bull trout (a290 mm) in Rapid River, 1993.

Tagged versus untagged	Size range (mm)	Number of fish trapped moving upstream	Early dropout[a]	Number of fish trapped moving downstream	Adjusted number of fish moving downstream[b]	Estimated mean survival	Mean condition factor (K)
Radio and	290-379[c]	0	-	-	-		
Ploy tags	380-449	13	4	5	9	69.2%	
	450+	19	0	8	8	42.1%	
		32	4	13	17	53.1%	0.739
Untagged	290-379	50	15	26	41	82.0%	
	380-449	46	14	24	38	82.6%	
	450+	19	0	17	17	89.5%	
		115	29	67	96	83.5%	0.782

[a] Four out of 13 (31%) radio-tagged bull trout 380-449 mm in length dropped back prior to the spawning period. We applied this dropout percentage to untagged fish in the 290-379 and 380-449 mm groups. No fish radio tagged over 450 mm dropped back.
[b] Adjusted higher for known (radio tagged fish) or estimated (untagged fish) dropout.
° Due to size constraints, no bull trout 5379 mm were radio tagged.

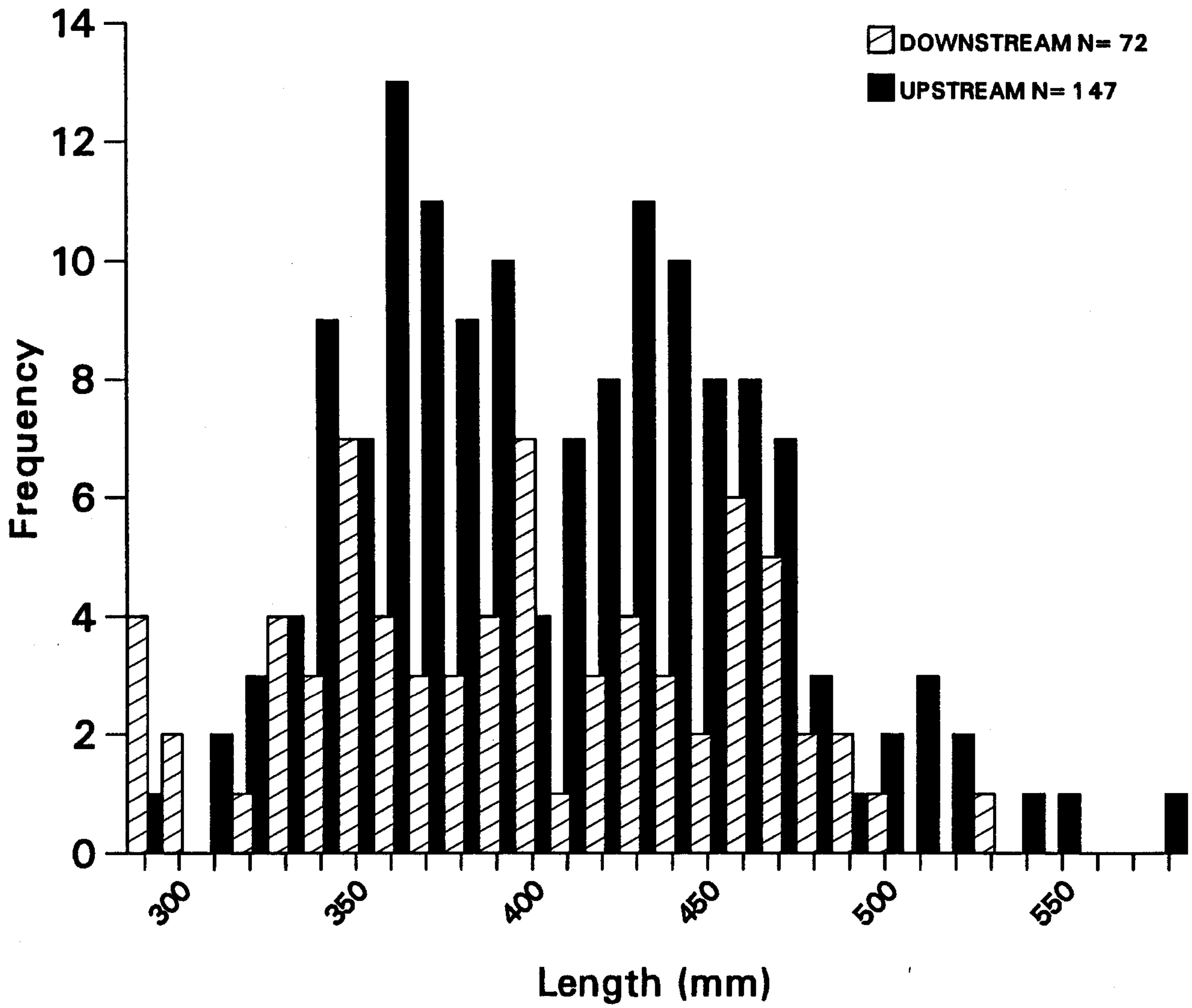

Figure 7. Length frequency comparisons for bull trout captured in Rapid River during upstream (May 12-August 16) and downstream (September 4-October 20) migrations, 1993.

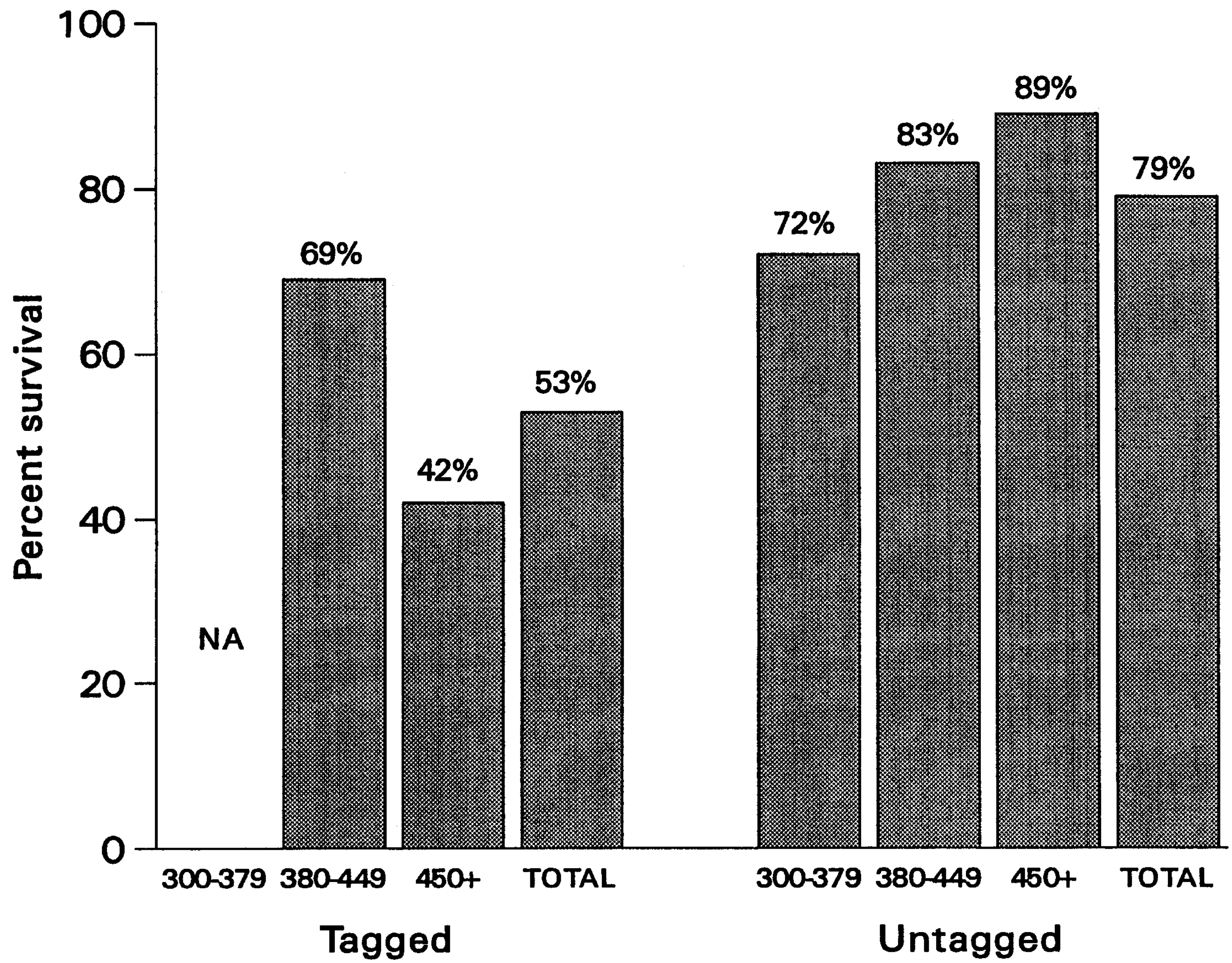

Figure 8. Survival of adult bull trout from upstream migration to downstream migration (post spawning) by size class in Rapid River 1993. Tagged fish were radio tagged and floy tagged. There were no significant differences between any survival rates.

Little Salmon River and one in the Salmon River. Three tagged fish could not be followed because we lost signals shortly after the fish exited Rapid River. One fish apparently died in the Little Salmon River and provided no habitat data.

Most tagged fish moved into the Salmon River within 2-3 weeks after exiting Rapid River. Fish distributed themselves over a distance of 114 km downstream of the mouth of Rapid River. Including movement within Rapid River, the longest distance travelled by a tagged fish equalled 165 km.

As in 1992 (Schill et al. 1994), fish overwintering in the Salmon River used pool and run habitats. We made 78 habitat use observations for 11 radio tagged bull trout over eight surveys dates from October 10 to March 31. Sixty-four (82%) of the observations were in pool habitat types. The remaining 14 locations were in run habitats.

Most overwintering bull trout showed strong site fidelity after entering the main Salmon River. Individuals typically remained in the habitat unit they selected after cessation of downstream movement to a given point in the river. Movements of 0-100 m were noted between observation dates but these were generally within a single habitat unit. One fish moved downstream 3+ km during December and then moved back to the same location it was observed in November. A second fish moved downstream in December and January. During March two fish moved upstream with one entering Rapid River by March 31.

DISCUSSION

During 1993, the increasing temperatures occurred after peak discharge and corresponded with a declining hydrograph (Figure 3). We reviewed trap counts and temperature data for years 1985 through 1992. In all but 1985 and 1989, a general trend of increasing upstream trap counts occurred as day time high temperatures reached 10°C. If available, historical flow data may be useful in further quantifying the relationship between discharge, temperature, and bull trout movement.

The presence of repeat spawners can greatly influence the reproductive capacity of a fish population. Repeat spawning females are generally larger and have more eggs than first time spawners. During 1993, four of the seven bull trout monitored through the fall and winter from 1992 radio tagging returned to Rapid River. One of the remaining three fish was harvested by an angler. A second tag signal disappeared from monitoring during the middle of the steelhead trout season. We suspect it was also harvested due to the strength of the signal and location in a preferred steelhead trout fishing hole prior to signal loss. Although the sample size is very small, a high proportion of bull trout in the Rapid River population appear to spawn in consecutive years. In Jack Creek, tributary to the Metolius River in Oregon, trap records indicate adfluvial bull trout repeat spawn in consecutive years (Ratliff et al 1994). Fluvial/Anadromous bull trout stocks in the Skykomish River in Puget Sound are considered consecutive year spawners (Curt Kraemer, Washington Department of Wildlife, personal communication). Allan (1980) documented consecutive year spawning in three separate tributaries of the Clearwater River, Alberta, Canada.

Approximately 50% of the adfluvial adult bull trout in Flathead Lake are believed to be alternate year spawners (Fraley and Sheppard 1989), but successive year spawning has also been documented.

Outmigrant bull trout juveniles (<300 mm) were primarily age 2+ and age 3+ during fall 1993 (see Job 2A). We captured no age 0 and only one age 1+ juvenile. Due to high water, we could not trap Rapid River during runoff to evaluate juvenile migration during spring and summer. Sheppard et al. (1984) found mostly age 2+ migrants with lesser numbers of age 3+ and age 1+ bull trout emigrating from Flathead River tributaries. Movement occurred primarily during June and July. In Idaho and British Columbia lakes, juvenile bull trout were also found to emigrate from rearing tributaries at ages 1+ to 3+ (Bjornn 1957; Oliver 1979; McPhail and Murray 1979). McPhail and Murray (1979) suggested a bimodal migration with primarily age 0 fish moving downstream in the spring and age 1+ and 2+ emigrating during the fall. Riehle and Weber (In Preparation) found the majority of bull trout emigration in Jack Creek, Metolius River, were age 0 fish during April, followed by a peak of age 2+ fish during May-July, with an increase in age 0 fish again in August and September. Juvenile bull trout trapped in Rapid River during fall 1993 were generally larger (180-290 mm) than those reported in the above studies. East Fork Salmon River emigrants were also smaller (130-210) than Rapid River fish (see Job 2A).

The presence of a spring outmigration of juvenile bull trout in Rapid River is unknown. High water temperatures in the Little Salmon and main Salmon rivers provide marginal summer rearing habitat for bull trout. Spring and early summer trapping would determine if a component of smaller, age 0 and age 1+ emigration occurs. This data will likely be available from future steelhead studies in Rapid River utilizing downstream screw traps. If this style of trap can capture juvenile bull trout with sufficient efficiency, a stock-recruitment function could be constructed for the stock. Since no such relation currently exists for the species, we recommend that quantification of juvenile outmigrants be attempted.

During 1993, estimated survival for radio tagged bull trout (53%) compared to untagged adults (79%) (Figure 7) was not significantly different ($P < 0.05$). The small sample size for tagged fish may have limited our inability to detect a significant difference, if in fact one did exist (Peterman 1990).

Several problems exist in our comparison of survival for radio tagged and untagged bull trout. Our double tagging of fish (floy and radio tags) may confound the comparison of survival estimates. McFarlane and Beamish (1990) found a significant survival reduction for floy tagged sablefish Anoplopoma, fimbria. We used floy tags for evaluation of radio tag loss and for observation of tagged fish on redds. We also evaluated angler exploitation using reward floy tags in 1993. Double tagging may have adversely influenced survival of radio tagged fish.

A second problem is the design of the picket spacing in the upstream chinook salmon trap. Hatchery personnel suspect small (< 350 mm) bull trout can pass through these pickets. It is not known if these bull trout can then pass upstream through the water control structure leading into the fish ladder. If small fish can migrate upstream without detection, then the number we used for untagged adults in the spawning run is too low and our untagged survival estimate would be positively biased.

Additional bias exists if bull trout >300 mm emigrated from Rapid River for the first time during fall 1993. We did not mark the untagged bull trout released upstream of the trapping facilities. Therefore, we would not be able to distinguish first-time outmigrants from upstream untagged fish during fall trapping.

Finally, we expanded the number of untagged bull trout 300-449 mm we captured in the downstream trap by a 31%. This equalled the percentage of radio tagged bull trout 380-449 which dropped out of Rapid River prior to installation of our downstream weir. We believe these fish may be subadults which do not spawn. In expanding the observed number of untagged fish, we assume a similar percentage of untagged and tagged bull trout moved downstream without detection at the weir. We assumed a similar or higher number of fish 300-380 mm are also subadults, and applied the 31% expansion factor to this group though we have no radio monitoring data for fish of this size.

All of the before mentioned design problems could result in an overestimate for survival of untagged bull trout, and possibly contribute to the difference in observed survival for radio tagged versus untagged groups. Obviously, results of our survival comparisons should be viewed with caution.

Additional data could be collected in 1994 to strengthen these results. Survival of untagged adults could be tested by marking all upstream migrant bull trout and operating a fall downstream trap. Such studies would answer questions regarding outmigration of fish not handled in our upstream trap. Based on length frequency comparison, some of the downstream migrants were clearly not included in our upstream counts (Figure 8). For small sizes of adult bull trout we captured more downstream than upstream migrants. At least five fish outmigrated which were not captured during upstream migration. This results in a positive bias in the survival of untagged bull trout.

We observed a slightly lower condition factor for radio tagged versus untagged groups of bull trout. The means were not significantly different, however. During a test of tag expulsion by hatchery rainbow trout we observed significantly lower condition factors ($P < 0.05$) in radio and floy tagged versus control fish (Steve Elle, IDFG, unpublished data).

Other researchers have documented shedding loss of surgically implanted radio tags. Marty and Summerfelt (1986) documented shedding through the intestine and the body wall by channel catfish Ictalurus punctatus. Chisholm and Hubert (1985) and Helm and Tyus (1992) showed similar tag loss for rainbow trout Oncorhychus mykiss. Mike Faler (USFS, personal communication) observed only one lost radio tag in spawning bull trout in the Lewis River. This was an adfluvial population and did not migrate as far nor spend as long in the spawning tributary compared to Rapid River. Phil Rhem (Alberta Environmental Protection, personal communication) observed tag losses from fluvial bull trout in Clearwater River, Alberta in 1992. He found two fish that lost tags and survived to capture as repeat spawners in spring 1993.

A major study objective was to determine if the 1992 spawning mortality estimates were biased by the shedding of radio tags. During 1993, 17 of 32 bull trout emigrated out of Rapid River following spawning with radios intact. At the downstream weir we did not observe any bull trout with surgery scars or a Ploy tag which did not also have a radio tag. Such fish would have indicated survival following tag expulsion during the 1992 spawning season. Based on our results, the spawning mortality estimates from 1992 and 1993 are not positively biased from tag expulsion. The *high* mortality estimates of tagged fish may result from predation, scavenging of carcasses following spawning mortality, or possibly from tag-related effects.

RECOMMENDATIONS

1. Improve our estimate of survival for untagged bull trout in Rapid River by marking all upstream migrants and follow up with outmigrant traps. Note appearance of any untagged fish over 300 mm to clarify results of this study.

2. Steelhead trout researchers plan to quantify steelhead trout recruitment from the Rapid River drainage over the next 5 years using screw traps. Include trap efficiency and outmigrant estimates of bull trout in that effort. A stock-recruit function could be constructed in the future.

ACKNOWLEDGEMENTS

Jason Vogel and John Guzevich assisted with much of the data collection. John and Tony Lamansky completed much of the data analysis. Dan Schill and Paul Kline assisted with ground surveys and contributed expertise on telemetry and surgical procedures. Rapid River Fish Hatchery personnel trapped and measured upstream migrant bull trout. Personnel from the New Meadows Ranger District assisted with vehicle shuttle support. Mike Dorris piloted all aerial surveys and provided for our safe return for the second consecutive season.

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A P P E N D I C E S

Appendix A. Sizes of bull trout and radio tags used in the Rapid River telemetry study.

Date tagged	Radio tag no.	Fish length (mm)	Fish weight (g)	Radio tag wt. (g)	Tag % of body wt.
06/16/93	150.225	455	925	10	1.08
06/16/93	150.145	448	1.000	10	1.00
06/16/93	150.165	476	1.050	10	0.95
06/16/93	150.135	507	1.225	10	0.82
06/16/93	150.355	427	900	6	0.67
06/18/93	150.035	520	1.375	10	0.73
06/18/93	150.015	478	1.150	10	0.87
06/18/93	150.095	453	875	10	1.14
06/18/93	150.294	476	1.125	10	0.89
06/18/93	150.375	430	875	6	0.69
06/18/93	150.274	475	1.075	10	0.93
06/28/93	159.305	395	616	6	0.97
06/38/93	150.324	400	630	6	0.95
06/28/93	150.315	414	640	6	0.94
06/28/93	150.534	564	1.790	20	1.12
06/28/93	150.505	463	1.085	10	0.92
06/29/93	150.525	482	1.110	10	0.90
06/29/93	150.545	506	1.375	10	0.73
06/29/93	150.385	417	715	6	0.84
06/28/93	105.565	490	1.090	10	0.92
06/29/93	150.585	473	1.195	10	0.84
06/06/93	150.344	467	1.180	6	0.51
07/07/93	150.605	441	800	10	1.25
07/07/93	150.625	465	975	10	1.03
07/07/93	150.645	467	950	10	1.05
07/07/93	150.404	390	500	6	1.20
07/07/93	150.422	397	535	6	1.12
07/08/93	150.665	436	775	10	1.29
07/08/93	150.445	383	575	6	1.04
07/08/93	150.685	454	865	10	1.16
07/08/93	150.463	383	500	6	1.20
07/21/93	150.025	600	2.235	20	0.89

Appendix B. PIT and floy tag data files for bull trout captured at Rapid River, 1993.

Date	Length	Weight	Pit tag no.	Floy tag no.	1993 Scale sample no.
09/06/93	198	0	7F7DOD7EOB		
09/13/93	272	0	7F7D0B7A04		
09/13/93	242	0	7F7D0D607D		113
09/13/93	262	0	7F7D0D7370		123
09/13/93	232	0	7F7D0D6029		107
09/13/93	225	0	7F7D0D6C29		104
09/13/93	280	0	7F7D0D6079		133
09/13/93	285	0	7F7D0B651B		137
09/13/93	308	0	7F7DOD5C1C	B1863	141
09/13/93	350	0	7F7D0B621D	B1864	149
09/16/93	222	0	7F7D0D5B5F		99
09/17/93	253	0	7F7D0B625E	B1875	117
09/17/93	236	0	7F7D0D604A		108
09/17/93	234	0	7F7D0D5C39		109
09/21/93	433	676	7F7DOD5D3C	R1913	
09/21/93	244	108	7F7D0B745C		
09/21/93	429	605	7F7D0B6938		
09/21/93	465	790	7F7D0C1657	B1873	185
09/21/93	203	84	7F7D0D6F62		85
09/21/93	487	885	7F7D00077F	B1872	192
09/21/93	252	135	7F7D0D7A49		119
09/21/93	408	545	7F7DOD6C7E	B1871	172
09/21/93	207	76	7F7D0B7366		86
09/21/93	435	690	7F7D0D637C	B1870	177
09/21/93	196	74	7F7D045030		81
09/21/93	212	78	7F7D0D7321		92
09/21/93	199	64	7F7D0C1757		77
09/21/93	200	66	7F7DOD6E4E		83
09/21/93	198	62	7F7DOA2B4A		78
09/21/93	454	750	7F7DOB6A7A	B1869	181
09/21/93	252	125	7F7DOD7DOA		118
09/21/93	473	808	7F7D0D704A	R1037	188
09/21/93	206	71	7F7D0B7755		88
09/21/93	460	760	7F7D0D6048	B1855	183
09/21/93	360	332	7F7D0B7500	B1868	154
09/21/93	447	580	7F7D0D612E	B1867	180
09/21/93	403	583	7F7D0D7366	B1866	170
09/21/93	222	86	7F7D0D5D7F		102
09/21/93	400	622	7F7D0B6267	B1865	168
09/21/93	470	820	7F7D0B7354	B1827	187
09/21/93	330	305	7P7D0B7635	B1828	142
09/21/93	337	295	7F7DOD6A6C	B1829	144
09/21/93	465	790	7F7D0D7245	B1830	184
09/22/93	223	94	7F7DOD7DOB		100
09/22/93	211	78	7F7D0D7537		94
09/22/93	204	68	7F7D0D5C18		89
09/22/93	232	100	7F7D0D607E		105
09/22/93	267	160	7F7D0D7477		125
09/22/93	405	585	7F7D0D5D56	B1831	171
09/22/93	210	72	7F7D0C1862		95
09/22/93	440	615	7F7D0B7762	B1832	178

J1 APB

Appendix B. continued

Date	Length	Weight	Pit tag no.	Floy tag no.	1993 Scale sample no.
09/22/93	206	72	7F7D0D5E06		90
09/22/93	232	108	7F7DOD7B3C		106
09/22/93	205	72	7F7D0B623E		84
09/22/93	229	96	7F7D0D7179		98
09/22/93	215	80	7F7DOD5D7E		91
09/22/93	212	78	7F7D086961		97
09/22/93	197	72	7F7D0D6809		80
09/22/93	367	500	7F7D0D6853	B1833	155
09/22/93	206	80	7F7D0D760F		87
09/22/93	183	52	7F7D0D7E09		73
09/22/93	196	64	7F7B0F506D		82
09/22/93	197	58	7F7B0A6504		
09/22/93	228	100	7F780FOD7C		101
09/22/93	183	52	7F7B0F1101		74
09/22/93	218	92	7F7B08651C		93
09/22/93	188	54	7F7B0E5E27		70
09/22/93	196	60	7F7B115720		
09/22/93	183	48	7F780F6D18		
09/22/93	210	92	7F7B0F4654		
09/22/93	213	78	7F7B093977		
09/22/93	225	104	7F7B116469		
09/22/93	214	82	7F78102C31		
09/22/93	266	160	7F7B0F664F		124
09/22/93	251	135	7F7D7F5E40		
09/22/93	215	88	7F780E5427		
09/22/93	208	66	7F7B0F3A28		
09/22/93	218	88	7F780E713B		
09/22/93	198	70	7F7B0F1127		
09/22/93	196	70	7F7B10162B		
09/22/93	205	74	7F7B0E5E64		
09/22/93	400	420	7F7B101B29	B1834	167
09/22/93	210	76	7F7B0E3736		
09/22/93	215	76	7F7B0E5A00		
09/22/93	262	155	7F7B0F5F2A		121
09/22/93	468	740	7F7B0E4954		186
09/22/93	218	84	7F7D7F5447		
09/22/93	208	74	7F7B0F6076		
09/22/93	220	86	7F7B0E4715		
09/22/93	432	630	7F7B08057B	B1836	
09/22/93	216	94	7F7B090112		
09/22/93	263	165	7F780F7E52		
09/22/93	222	72	7F7B0F3545		
09/22/93	358	360	7F7B0F416A	B1837	152
09/22/93	203	64	7F7BOE3ElA		
09/22/93	250	130	7F7BOE7AOB		122
09/22/93	221	86	7F7B0E371D		
09/22/93	278	175	7F7B0F386F		132
09/22/93	234	107	7F780F483B		
09/22/93	226	92	7F7B0F231B		
09/22/93	282	180	7F7B0F1553		135
09/22/93	375	435	7F7810202B	B1838	159
09/22/93	189	56	7F7D7F6954		

J1 APB

Appendix B. continued

Date	Length	Weight	Pit tag no.	Floy tag no.	1993 Scale sample no.
09/22/93 .	190	56	7F780F161E		
09/22/93	215	80	7F7B101767		
09/22/93	193	61	7F7B10085C		
09/22/93	211	80	7F7B08435E		
09/22/93	236	112	7F7BOF1D2B		
09/22/93	277	190	7F7D7F6B66		131
09/22/93	207	72	7F7B0F0673		
09/22/93	203	68	7F7D7F736A		
09/22/93	216	94	7F7D7F6043		
09/22/93	202	67	7F7B08660C		
09/22/93	222	96	7F7B0E5B02		
09/22/93	237	100	7F7BOE6E2B		
09/22/93	372	430	7F7D7F6A01	B1839	158
09/22/93	355	310	7F7B10081B	B1840	151
09/22/93	220	82	7F7B0E5231		
09/22/93	418	420	7F7B0F710E	B1841	174
09/22/93	191	62	7F7B0E4061		
09/22/93	206	76	7E7E100106		
09/22/93	383	440	7F7B0E637A	B1842	161
09/22/93	195	64	7F7B0F0E56		
09/22/93	220	90	7F7B077332		
09/22/93	243	123	7F7B0F7741		114
09/22/93	228	101	7F7B0F3742		
09/22/93	264	160	7F7B0E6256		
09/22/93	248	140	7F7D7F737A		116
09/22/93	198	68	7F7B0E4D02		
09/22/93	205	76	7F7BOE7A4E		
09/22/93	242	112	7F7B0A7C24		
09/22/93	205	70	7F7B116825		
09/22/93	371	520	7F7B101950	B1843	157
09/22/93	251	135	7F7B0E4562		120
09/22/93	215	78	7F7D445933		
09/22/93	208	69	7F7D7F6879		
09/22/93	220	88	7F7B0E555E		
09/22/93	206	78	7F7B0E6479		
09/22/93	475	840	7F7B0E4F46	B1844	189
09/22/93	444	600	7F7D7F720B	B1845	179
09/22/93	422	650	7F7BOF5D4D	B1846	175
09/22/93	233	88	7F7D7F673C		
09/22/93	282	195	7F7B0F584F		134
09/22/93	208	70	7F7B0E5865		
09/22/93	476	810	7F7B083C79	B1847	190
09/22/93	228	100	7F7B0E6D68		
09/22/93	270	185	7F780F162F		
09/22/93	209	82	7F7BOF7C5B		
09/22/93	253	150	7F7B0F531E		
09/22/93	251	140	7F7D7F613C		
09/22/93	198	74	7F7B0E5408		
09/22/93	290	228	7F7BOE4430		
09/22/93	298	248	7F7B0F4133		
09/22/93	345	364	7F780F0E65	B1848	147
09/22193	350	340	7F7B102C71	B1849	148

J1 APB

Appendix B. continued

Date	Length	Weight	Pit tag no.	Floy tag no.	1993 Scale sample no.
09/22/93	298	237	7F78115E1B		
09/22/93	359	380	7F7808727F	B1850	153
09/22/93	297	220	7F7B0F7722		139
09/22/93	380	430	7F78116D21	B1826	160
09/23/93	216	88	7F7B0E793C		
09/23/93	198	62	7F7B0F0809		
09/23/93	195	62	7F7B0E7F4A		
09/23/93	210	86	7F7B0A2E11		
09/24/93	245	126	7F7B102A6B		
09/24/93	215	82	7F7B0F1958		
09/24/93	218	68	7F7B0F0413		
09/24/93	219	86	7F7B0F4C70		
09/24/93	282	185	7F7B0F4570		136
09/24/93	198	70	7F7B11542C		
09/24/93	221	87	7E780E3333		
.09/24/93	220	74	7F7B0E5C50		
09/24/93	215	92	7F7B0F5346		
09/25/93	220	88	7F7B0E790C		
09/25/93	200	60	7F78101E19		
09/25/93	229	100	7F7B0E4459		
09/26/93	236	124	7F780E703A		110
09/26/93	242	110	7F7811663B		
09/26/93	226	98	7F7BOF6FOO		
09/26/93	224	92	7F78116258		
09/26/93	248	118	7F7B0F752E		
09/26/93	275	170	7F7B0F3775		
09/26/93	259	148	7F7B0F1A24		
09/28/93	213	80	7F7B0F4833		96
09/28/93	198	62	7F7B0F1638		79
09/28/93	268	158	7F7D7F5E60		126
09/28/93	180	50	7F7B0E3027		75
09/28/93	243	122	7F78096E49		115
09/28/93	390	392	7F7B0E456C		
09/28/93	232	116	7F7B0F1409		
09/28/93	262	140	7F7D7F4B78		
09/28/93	268	168	7F7808674C		127
09/29/93	223	62	7F7D7F584F		103
09/29/93	230	90	7F7BOA6F2A		112
09/29/93	386	420	7F7D7F526C	B1861	162
09/29/93	184	54	7F7B0F387E		
09/29/93	392	524	7F7B0A0B65	B1876	165
09/29/93	355	367	7F780E4C41	B1899	
09/29/93	235	112	7F7B0E5752		111
09/29/93	262	130	7F7B0F372A		128
09/29/93	274	180	7F780E7F51		130
09/29/93	499	916	7F78087368	B1911	
09/29/93	250	150	7F7D7F6059		
09/29/93	240	116	7F78102831		
09/29/93	226	106	7F7B0E567D		
09/29/93	199	62	7F7811644F		76
09/29/93	249	130	7F7809226D		
09/29/93	42	124	7F7B0F7045		145

J1 APB

Appendix B. continued

Date	Length	Weight	Pit tag no.	Floy tag no.	1993 Scale sample no.
09/29/93	333	286	7F7B0E306E	WA726	143
09/29/93	219	88	7F7B0A7261		
09/29/93	211	72	7F780F157C		
09/29/93	268	170	7F7B0F255D		
09/29/93	301	230	7F7B0F765B	WA727	140
09/29/93	486	840	7F7B092B1E	WA729	191
09/29/93	390	500	7F7B074245	WA728	163
09/29/93	367	450	7F7B090016	WA730	156
09/29/93	393	490	7F7D7F5F55	WA731	166
09/29/93	400	510	7F7B0F4430	WA732	169
09/29/93	496	935	7F7BOF511B	WA733	
09/30/93	219	80	7F7B0A0D25		
09/30/93	187	52	7F7B0F4139		
09/30/93	231	100	7F7B0F046F		
09/30/93	223	64	7F7B10296E		
09/30/93	215	84	7F7B0E3C76		
09/30/93	252	118	7F730E4F09		
09/30/93	242	102	7F7B090729		
10/01/93	212	76	7F7B0F0668		
10/01/93	266	130	7F7B0F1401		
10/01/93	242	118	7F7B0E7732		
10/01/93	232	104	7F7B0E4256		
10/01/93	210	80	7F7BOF7C6D		
10/02/93	205	68	7F7B090304		
10/02/93	217	86	7F7B0E4107		
10/02/93	323	98	7F7B0F4106		
10/02/93	184	52	7F7B0F1D23		
10/02/93	195	58	7F7B0F2Al2		
10/02/93	225	92	7F7B0F236D		
10/02/93	244	122	7F7B115533		
10/02/93	190	56	7F7B0E4861		
10/02/93	271	155	7F7B0E343F		
10/03/93	532	940	7F7B101E7B	B1917	
10/04/93	197	64	7F7B080041		
10/04/93	208	68	7F7BOE4B2A		
10/04/93	237	102	7F7B0E590E		
10/04/93	203	66	7F7B070221		
10/05/93	190	60	7F7B0F5806		
10/05/93	247	128	7F7B0F710A		
10/05/93	167	36	7F7B0E357B		
10/06/93	215	84	7F7B10147B		
10/06/93	205	51	7F7B100324		
10/06/93	234	104	7F7B10052D		
10/06/93	208	72	7F7B087241		
10/06/93	198	68	7F7B094905		
10/06/93	207	86	7F7B0E6170		
10/06/93	210	82	7F780F4939		
10/06/93	230	98	7F7B115224		
10/06/93	216	86	7F7B0E5126		
10/07/93	210	72	7F7D3F4C09		
10/07/93	205	68	7F7E693D4E		
10/07/93	245	120	7F7D3F3849		

J1 APB

Appendix B. continued

Date	Length	Weight	Pit tag no.	Floy tag no.	1993 Scale sample no.
10/07/93 _	236	104	7F7D3F6808		
10/07/93	208	72	7P7D3E2C43		
10/07/93	235	102	7F7D3F347B		
10/07/93	230	104	7F7D2D5C47		
10/07/93	205	70	7F7E686C34		
10/07/93	245	124	7F7D313766		
10/07/93	245	112	7F7D3E1C5D		
10/07/93	332	320	7P7D3E3140	WA740	
10/07/93	360	390	7F7E686961	WA741	
10/07/93	234	110	7F7D343D73		
10/07/93	270	190	7F7D3E1B32		
10/07/93	502	940	7F7D3F6656	WA742	
10/07/93	260	150	7F7D3F2973		
10/08/93	215	76	7F7D3E1412		
10/08/93	200	74	7F7D3E347B		
10/09/93	180	50	7F7D3E2801		
10/11/93	195	66	7F7D3E323A		
10/11/93	343	324	7F7D3E3613	WA743	146
10/11/93	193	60	7F7D3E253E		
10/11/93	432	610	7F7D3E266D	WA744	176
10/11/93	456	820	7F7D3F727C	WA745	182
10/11/93	352	332	7F7D3F3932	WA746	150
10/12/93	207	76	7F7D3F3816		
10/12/93	185	51	7F7D2C692F		
10/15/93	200	66	7F7E686962		
10/15/93	224	98	7F7D3E1B08		
10/15/93	222	98	7F7D3E2B72		
10/15/93	220	116	7F7D313879		
10/15/93	255	168	7F7D3F7023		
10/15/93	250	178	7F7D3F6748		
10/15/93	216	66	7F7D3E2D65		
10/15/93	211	0	7F7D3E1B12		
10/15/93	468	800	7F7D3F5A09	WA747	
10/15/93	467	700	7F7D312F09	B1923	
10/15/93	420	600	7F7D3F6741	WA748	
10/15/93	473	700	7F7D3F3852	WA749	
10/15/93	405	460	7F7D3F6A7E	B1906	
10/15/93	344	380	7F7D31290C	WA750	
10/15/93	237	110	7F7D3E235A		
10/19/93	255	169	7F7E6A4E54		
10/19/93	240	160	7F7D3F6746		
10/20/93	233	123	7F7D3F742A		

JOB PERFORMANCE REPORT

State of: **Idaho**

Name: **River and Stream Investigations**

Project No.: **F-73-R-16**

Title: **Bull Trout Aging Studies**

Subproject No. **II**

Job: **2A**

Study No. **IV**

Period Covered: **April 1. 1993 to March 31. 1994**

ABSTRACT

We compared age estimates from scales and otoliths for fluvial bull trout *Salvelinus confluentes* from Rapid River and East Fork Salmon River (EFSR). Analysis indicated faster growth at early ages compared to other western streams. Estimates from scales and otoliths agreed in 75% of the 52 paired samples from Rapid River and 57% of the EFSR samples (n = 14). Aging from otoliths produced high percent agreement between readers and lower average percent error between readers and between structures compared to scales. Disagreement between scale and otolith estimated ages were never more than 1 year. The slope of the observed scale-otolith regression lines were not significantly different from a hypothetical 45° line representing 100% agreement. Scales appear to provide a basis for aging of Idaho bull trout stocks. Future PIT tagging and subsequent monitoring of known-aged fish should be done before scales are considered an accurate aging structure, however. Priority should be given to incorporate bull trout marking and monitoring of known-age fish into other fisheries projects.

Authors:

Steven Elle
Senior Fishery Research Biologist

Tony Lamansky
Fishery Technician

INTRODUCTION

Very little is known of the life history of fluvial bull trout Salvelinus confluentus in Idaho. Age determination is one of the most important aspects of fish population dynamics (Ricker 1973; Beamish and McFarlane 1983). Numerous methods for aging fish exist: length frequency analysis, known age involving mark-recapture and analysis of bony structures (Majkowski and Hampton 1983; Everhart and Youngs 1981; McNew and Summerfelt 1978). We did not have the opportunity to mark an adequate segment of the study populations prior to our study. Therefore, we used scales and otoliths for aging and comparison. A limited number of aging studies have been conducted on bull trout in Idaho (Schill 1991; Pratt 1985; Irving 1986; Thurow 1987; Corsi and Elie 1989). Many of the studies relied on small sample size and only one had a sample size large enough to allow an estimate of total mortality (Z).

Most of the above studies have relied on scales as the sole aging structure. In recent years, scales have been shown to be unreliable for aging several species of char including lake trout Salvelinus namaycush and arctic char Salvelinus arcticus (Baker and Timmons 1988; Beamish and McFarlane 1983 and 1987; Barber and McFarlane 1987; Power 1978). Schill (1991) reported consistently older age estimates using otoliths compared to scales in a limited sample of Idaho bull trout. Schill (1992) reported comparable age determinations for bull trout from Lake Pend Oreille using otoliths, scales, and fin rays.

Accurate age estimates are necessary to properly evaluate a fish stock. If age estimates are inaccurate, serious mismanagement of the stock may result. The concern in using scales for char usually lies in assigning ages to older fish; they are often underestimated (Barber and McFarlane 1987; Power 1978).

Lack of validation for any aging structure raises questions about the reliability of age determinations (Beamish and McFarlane 1983). A limited degree of confidence is attained, however, by comparing age determinations of several structures for individual fish (Beamish and McFarlane 1983; Lorson and Marcinko 1990; Mills and Beamish 1980; Barber and McFarlane 1987). Percent agreement between structures provides a measure of comparison of two or more structures. Percent agreement, however, only measures whether an age agrees between structures or readers. It does not measure the magnitude of difference in age between determinations or the number of age classes in the population (Laine and Momot 1991).

Average percent error (APE) (Beamish and Fournier 1981) allows for comparison of precision among individual readers and/or structures. A smaller degree of error between structures or readers results in more confidence being placed on the age estimates. Compared with percent agreement, the index of APE is a better measure of precision because it takes into account the difference in age determinations and number of age classes.

OBJECTIVES

Research Goal: Provide sufficient life history data to maintain and restore bull trout for trophy fishing opportunities.

1. To estimate growth rates of bull trout stocks from various Idaho waters.

2. To determine the best structures for aging stocks of fluvial bull trout in Idaho.

METHODS

Sampling

Rapid River

We collected scales from 146 bull trout sampled from angler creels and traps adjacent to the Rapid River Fish Hatchery in 1992 and 1993 (see Job 1). Scale samples were also taken from 30 fish collected by electrofishing in 1993 from Granite Fork and Lake Fork, tributaries in the headwaters of Rapid River. We collected otoliths from 24 of the same fish.

Scale samples were taken from the left side of fish between the lateral line and the posterior insertion of the dorsal fin. We stored scales in coin envelopes with total length, weight, and date of sample recorded on the envelopes. Otoliths were stored in a 1:1 glycerine/water solution. One hundred seventy-one scale and 63 otolith samples were suitable for aging, 52 of which were paired. Fish in our sample ranged from 47-615 mm total length.

East Fork Salmon River

We sampled bull trout from the East Fork Salmon River (EFSR) in a similar manner as Rapid River. We collected 86 scale samples from fish moving upstream past an anadromous hatchery trap in 1991. Shoshone-Bannock tribal biologists collected 66 scale samples at a downstream screw trap in 1993, located downstream of the satellite trap. Otoliths and scales were also collected from nine juvenile fish in the upper East Fork Salmon River and five in West Pass Creek, a tributary. We collected paired structures from a spawning mortality in 1992. Of the total sample, 144 scales and all 15 otoliths were suitable for aging; there were a total of 14 paired samples. Fish ranged from 134-721 mm total length.

Structure Preparation and Aging

Scales

We examined scales using a dissecting scope. A minimum of six readable scales were removed and pressed on separate, labeled acetate slides (Chilton and Beamish 1982). If six could not be found, as many as possible were used.

Scales were projected using a microfiche machine. Criteria we used to identify annuli were crowding and/or crossing over of circuli (Chilton and Beamish 1982). Scales were read once by two readers and age was recorded. After all scales were aged, estimates resulting in disagreement were read jointly to determine a final age (Lorson and Marcinko 1990). We digitized scale annulus, focus, and margin measurements on a Texas Instruments Hipad. Back calculated lengths-at-age were determined using the DISBCAL 89 program (Missouri Department of Conservation 1989). We used Texas Instruments Hipad Plus digitizing board to record scale measurements. We used 45 mm total length as the size at squamation for back calculating length-at-age for scales (Pratt 1991).

Otoliths

Otoliths were surface aged using a dissecting microscope with reflected or transmitted light (Chilton and Beamish 1982). Otoliths were aged once by three readers. Again, any disagreement resulted in joint readings to determine a final age. Annuli were measured under reflected light using an ocular micrometer with the microscope on high power. Annuli were identified by the presence of light bands. These winter growth zones appeared dark under transmitted light (Chilton and Beamish 1982). Back calculated lengths at age were determined using DISBCAL89.

Structure Comparisons

Readers had no knowledge of fish lengths or capture dates during the reading of any structures. Paired structures were read independently of each other. We graphically compared age estimates from paired scale and otolith samples from both waters. A plot of scale age to otolith age should have a slope of 1.00 if there is 100% agreement (Lorson and Marcinko 1990; Barber and McFarlane 1987). Estimates of scale and otolith age were plotted and regression statistics calculated. We tested a null hypothesis of no difference in age estimates between structures by statistically comparing the regression slope to 1.00 (Zar 1984).

We determined percent agreement and the index of average percent error between structures and between readers. Percent agreement was calculated as the proportion of times age estimates were the same or within 1 or 2 years. We calculated average percent error as follows:

$$\frac{1}{R}\sum_{i=1}^{R}\frac{|X_{ij}-X_j|}{X_j} \qquad (1)$$

Where:

R = Number of times each structure is aged.
Xu = ith age determination of the jth fish.
X_i = the average age of the jth fish.

Multiplied by 100, this becomes the average percent error of the jth fish.

$$\frac{1}{N}\sum_{j=1}^{N}\left[\frac{1}{R}\sum_{i=1}^{R}\frac{|X_{ij}-X_j|}{X_j}\right] \qquad (2)$$

Where:

N = number of fish aged.

RESULTS

Rapid River

Age estimates in the sample ranged from 0-6. We encountered extensive variability in age of similar sized fish. We developed an age-length key based on the larger scale sample for 1992-93 (Appendix A).

Estimates of length-at-age (LAA) from scales generally exceeded those for otoliths, although the two estimates were similar for each age group. LAA estimates for scales ranged from 115 mm at age 1 to 466 mm at age 6 (Table 1). LAA estimates for otoliths ranged from 85 mm at age 1 to 495 mm at age 6. Lengths at age 1 were based on sample sizes of one and eight fish for scales and otoliths, respectively.

Reader percent agreement was higher for otoliths (83%) than scales (65%)(Table 2). APE was nearly 50% lower for otoliths versus scales. Both these calculations, indicate a higher repeatability in results determined from otoliths compared to scales.

Scale versus otolith comparisons provided the same age in 39 of 52 (75%) paired samples (Figure 1)(Table 2). APE equaled 5.9% for scale versus otolith ages. In the cases where estimates of scale and otolith age differed, the difference was only 1 year (Figure 1). In the 13 cases of disagreement in age determinations between structures, otoliths indicated older fish 11 times and

Table 1. Comparison of back-calculated length-at-age for bull trout from Rapid River. Ages determined based on scale and otolith samples collected during summer and fall 1993.

Age group	N	Calculated mean total lenath (mm) at annulus 1	2	3	4	5	6
			Scales				
I	19	87					
II	45	112	168				
III	70	116	176	238			
IV	23	134	201	275	342		
V	10	127	185	252	324	409	
VI	3	119	180	245	309	385	466
Weighted grand mean		115	178	247	334	404	466
Number of fish		170	151	106	36	13	3
Incremental growth		115	63	69	87	70	62
			Otoliths				
I	19	78					
II	6	68	125				
III	18	92	152	206			
IV	4	87	153	205	257		
V	4	100	143	211	265	325	
VI	4	90	179	260	320	412	495
Weighted grand mean		85	149	214	281	368	495
Number of fish		55	36	30	12	8	4
Incremental growth		85	64	65	67	87	127

J2A_T1

Table 2. Percent agreement and average percent error (APE) for between reader aging precision for bull trout using scales and otoliths in Rapid River and East Fork Salmon River.

			Percent aareement			
Body of water	Structure	N	Complete	Within one year	Within two years	APE
Rapid River	scales	172	65	-	-	7.6
	otoliths	63	83	-	-	4.4
	scales vs otoliths	52				
	Reader 1		58			10.5
	Reader 2		73			5.1
	Reconciled[a]		75	100	100	5.9
East Fork Salmon River	Scales[b]	142	62			7.3
	Otoliths[c]	15	74			3.3
	scales vs otoliths	14				
	Reader 1		57			7.7
	Reader 2		79			3.9
	Reader 3		50			6.9
	Reconciled`		57	100	100	7.3

[a] When differences between readers existed, we jointly reviewed structure to determine an agreed upon age.
[b] Two readers.
[c] Three readers.

J2A T2

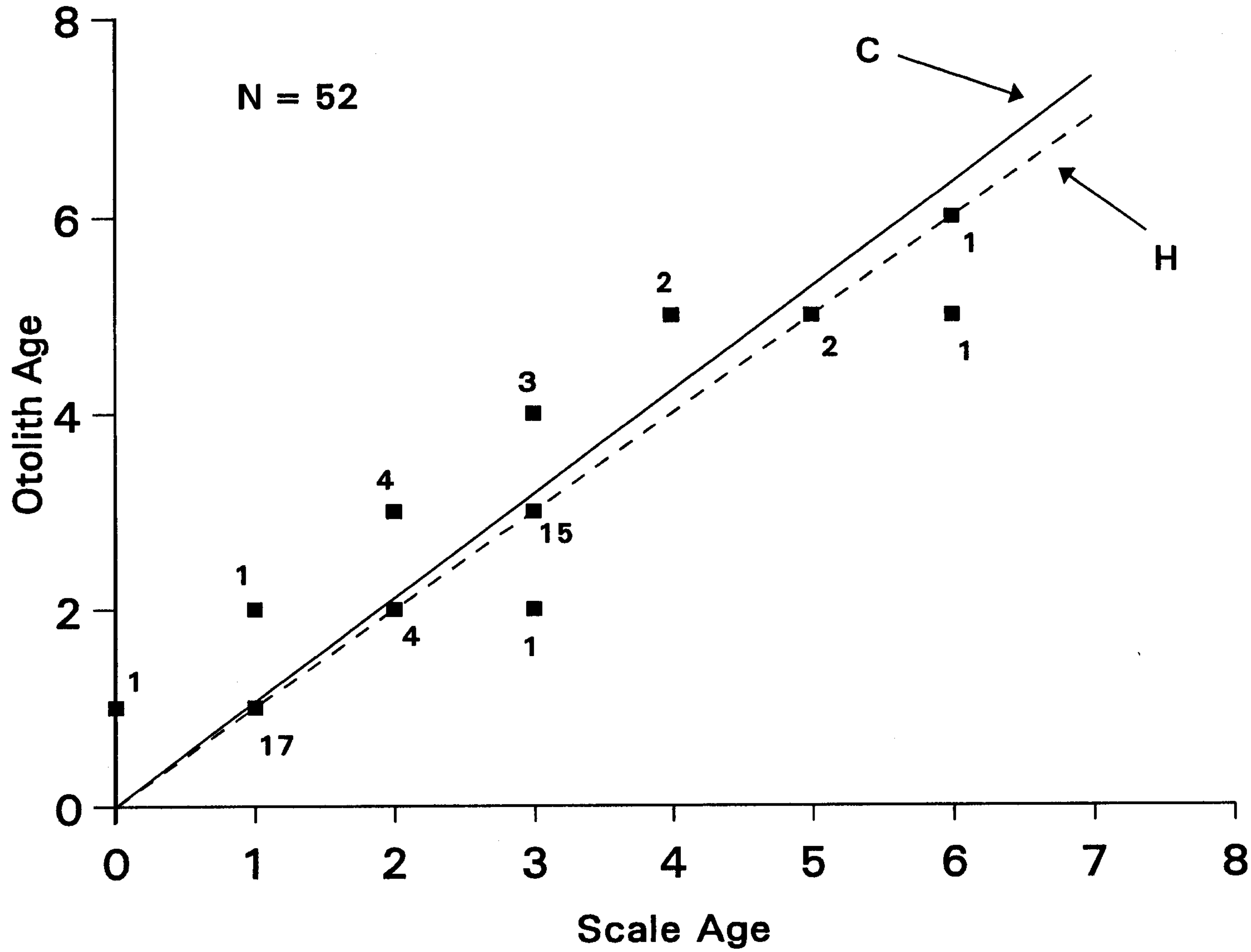

Figure 1. Comparison of scale/otolith ages for bull trout from Rapid River (H = hypothesized slope = 1.00, C = calculated slope = 1.06).

scales indicated older fish twice. There was no statistical difference ($P > 0.47$) for the difference in the slope between the hypothesized line of complete agreement and the observed scale-otolith regression line.

East Fork Salmon River

Fish ranged from 134-721 mm total length and encompassed age groups 1 through 7 (Table 3). We did not obtain a large enough sample of otoliths to estimate LAA as we did at. Rapid River.

LAA estimates for scales ranged from 124 mm for age 1 to 655 at age 7 (Table 3). Bull trout from EFSR grew faster compared to Rapid River fish. Like Rapid River, the fish sampled in ESFR did not include any age 0 fish and few age 1+ bull trout.

Percent agreement between readers for all comparisons equalled 62% and was similar to the estimate for Rapid River. Otolith percent agreement was again higher compared to scales. EFSR otolith agreement was lower than Rapid River, possibly due to the addition of a third reader. APE for Otoliths was lower compared to scales (Table 2).

Scale versus otolith comparisons provided the same age in 8 of 14 paired samples in EFSR (Table 2). As in Rapid River, differences between otoliths and scales did not exceed one year and APE equalled 7.3%. For the limited sample, scale ages exceeded otolith ages in four of six cases (Figure 2), which is opposite the trend observed in Rapid River. The slopes of the hypothesized (slope= 1.0) and observed (slope = 0.91) regression lines were not significantly different ($P > 0.50$).

DISCUSSION

Based on estimates of 115 to 124 mm at annulus 1, bull trout in Rapid River and EFSR grow more rapidly than other western populations (Table 4). We are concerned we missed the first annulus in our analysis. The criteria we used to identify annuli were the same as those in past efforts, however (Karen Pratt, K.L. Pratt Consulting, personal communication). We sampled a single young of the year bull trout 49 mm in length from upper Rapid River during September 29, 1993. We could not find any scales on this fish. Depending on the time of scale formation, Rapid River bull trout may not have time to lay down an annulus following scale formation late in the season (Lentch and Griffith 1987; Mallet 1963). For cutthroat trout Oncorhynchus clarki (Lewensky and Bjornn 1983; Mallet 1963; Laakso and Cope 1956) this process results in high circuli counts to the first annulus. We did not find this in our analysis but bull trout are a different species. If we missed an annulus or these fish do not form an annulus the first year, we have overestimated bull trout growth in both populations. Additional efforts should be made to document time of scale formation for bull trout in the two study streams.

Table 3. Back-calculated length-at-age for bull trout from East Fork Salmon River. Ages determined based on scale samples collected summer and fall 1992 and 1993.

Age group	N	Calculated mean total lenath (mm) at annulus 1	2	3	4	5	6	7
I	7	109						
II	48	108	159					
III	15	108	151	197				
IV	33	143	209	289	381			
V	30	137	201	272	354	440		
VI	10	129	201	272	355	438	525	
VII	1	163	244	315	382	480	593	655
Weighted grand mean		124	183	266	366	441	531	655
Number of fish		144	137	89	74	41	11	1
Incremental growth		124	59	70	86	86	89	62

J2A T3

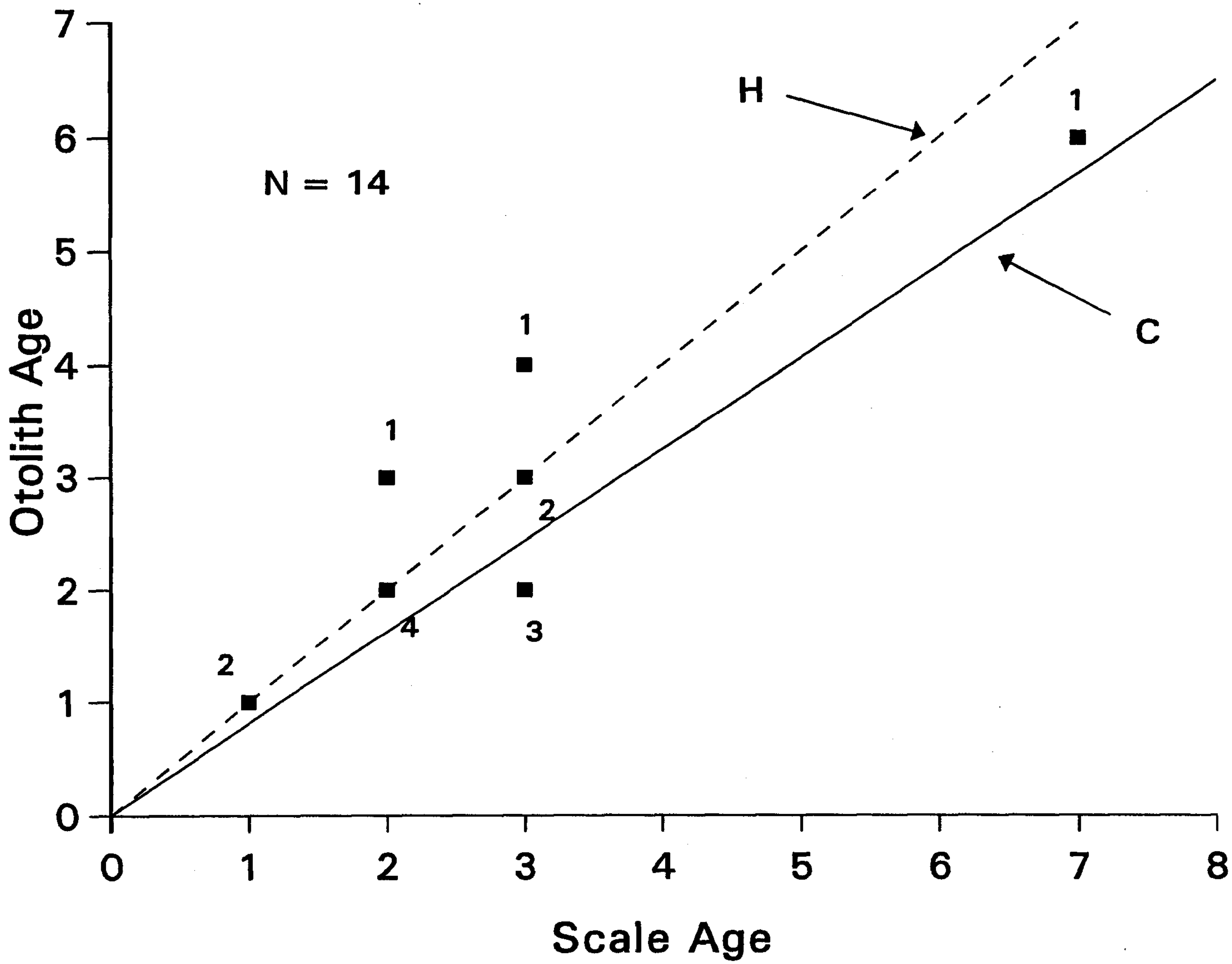

Figure 2. Comparison of scale/otolith ages for bull trout from East Fork Salmon River (H = hypothesized slope = 1.00, C = calculated slope = 0.91).

Table 4. Back-calculated length-at-age of bull trout from selected waters (adapted from data in the following reports: Leathe and Graham 1982; Shepard et al. 1982; Goetz 1989; Pratt 1991; Thurow 1987.

	Calculated mean total length (mml at annulus						
Water body	1	2	3	4	5	6	7
Salmon River Basin							
Rapid River							
scales	114	178	247	334	404	466	
otoliths	85	149	214	281	368	495	
East Fork Salmon River	124	183	266	366	441	531	655
South Fork Salmon River	68	110	154	217	284		
Metolius River Basin	72	130	196	290	433	633	821
Flathead River Basin							
Flathead Lake							
1963-1981	68	130	204	292	384	472	567
1955	76	150	234	335	457	566	691
1963	71	140	208	323	452	594	724
Upper Flathead tributaries	72	108	140				
Middle Fork Flathead	48	97	174	286	389	484	575
Hungry Horse Reservoir 1953 and 1972	72	144	225	324	429	513	594
Kootenay River Basin							
Lake Kookanusa	67	123	212	309	390	482	518
Toboggan Creek	48	99	165	229			
Wigwam River	64	114	176	385	476	557	668
Priest River Basin							
Priest Lake	71	114	183	310	424	516	605
Upper Priest Lake	66	102	155	239	358	462	546
Pend Oreille River Basin	91	164	272	403	497	578	

J2A T4

We did not have known aged bull trout to validate our estimated ages. High percent agreement or low APE for the aging structures provides a form of validation. In Rapid River, we had 75% agreement between scale and otolith age determinations. This rate is similar to Metolius River bull trout (Pratt 1991) and Pennsylvania brown trout *Salmo trutta* in freestone streams (Lorson and Marcinko 1990). However, in EFSR the percent agreement only equalled 57%. The lower percent agreement may result from the small sample size (n = 14). The small sample size in both waters, particularly for older fish, limit our comparisons and resultant confidence in either structure, however.

High levels of precision can exist between structures and still not be accurate in relation to the true age (Beamish and Fournier 1981). In our study, if both scales and otoliths fail to detect annuli at later ages, agreement between the structures will not ensure our age estimates equal true ages of bull trout.

We only used surface aging of otoliths in this analysis. We intend to check our otolith aging estimates with grinding and polishing, and crack and burning methods in the coming year. Although more time consuming, these methods can provide greater resolution for older fish.

Baker and Timmons (1988), Beamish and McFarlane (1983 and 1987), Barber and McFarlane (1987) and Power (1978) indicate otoliths provide superior age determinations for char, especially for older fish. We observed no statistical differences in age estimates between the structures but reader precision was higher for otoliths in both of our study streams. Based on our results and Schill (1991), we would prefer to utilize otoliths for future aging.

For many depressed bull trout stocks, however, sacrifice of fish to extract otoliths for aging will be hard to justify. Karen Pratt (K.L. Pratt Consulting, personal communication) and Shanye MacLellan (Nanaimo Fish Aging Lab, personnel communication) believe bull trout scales provided comparable results to otoliths up to 6 to 8 years of age on two adfluvial stocks. Based on our data, we believe scales can provide acceptable determinations of age in fluvial stocks. If recently adopted angling regulations (statewide catch-and-release for all bull trout) result in older age-classes, scales will likely be unsuitable for older fish based on other char studies cited above.

Because of the importance of accurate growth data for fish management decisions, age validation based on known-age fish should be commonplace (Beamish and McFarlane 1983). On both Rapid River and the EFSR, long-term hatchery trapping provides an opportunity to easily examine marked bull trout over a period of years. While conducting movement and exploitation studies on Rapid River, we collected and PIT tagged a total of 233 juvenile and 68 adult bull trout. PIT tagged bull trout should provide a validation of scale accuracy over a length range from 200 to 500 mm in the Rapid River population over the next 1-4 years as these fish return to spawn. Although the sample size is much smaller, Shoshone-Bannock tribal biologists are creating a similar opportunity tagging bull trout downstream migrants in EFSR. Other Idaho Department of Fish and Game crews operating upstream and downstream trapping facilities on the same river should collect scale samples and PIT tag all bull trout to provide additional age estimates and validation of scale as aging structures.

RECOMMENDATIONS

1. The use of scales for aging analysis for present Idaho bull trout populations is an acceptable method. Management decisions must recognize scale aging probably underestimates age for older bull trout by at least one year, resulting in overestimates in growth rates and underestimates of total mortality.

2. New harvest regulations closed the harvest of bull trout effective January 1, 1994. Bull trout harvest restrictions may result in older individuals. Comparative structure aging should be repeated in 3-6 years to ensure accurate age and resultant mortality estimates.

3. Utilize PIT tagged bull trout in Rapid River and EFSR for age validation of this study. Coordinate with other Department projects to ensure collection of scale samples and application of PIT tags to juvenile bull trout for additional age validation in other Idaho streams.

ACKNOWLEDGEMENTS

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Appendix A. Percentage of fish by age and length based on scale analysis for bull trout, Rapid River 1993.

RAPID RIVER AGE KEY

N	Length	Age 0	Age I	Age II	Age III	Age IV	Age V	Age VI
1	80		100					
3	90	33	67					
5	100		100					
7	110		100					
2	120		100					
2	130		100					
2	140			100				
1	150			100				
0	160							
1	170		100					
6	180			100				
9	190			100				
8	200			75	25			
9	210			89	11			
10	220			20	80			
11	230			36	64			
7	240			29	71			
8	250			25	75			
8	260				100			
5	270				100			
6	280			33	67			
4	290				100			
4	300				100			
0	310							
0	320							
4	330				50	50		
2	340			50	50			
7	350			14	57	29		
3	360				33	67		
4	370					100		
3	380				100			
4	390				25	50	25	
6	400				16	50	34	
3	410				33	67		
1	420					100		
2	430					50	50	
1	440					100		
2	450					50	50	
4	460					50	25	25
4	470					75	25	
2	480					50	50	
0	490							
0	500							
0	510							
0	520							
0	530							
0	540							
0	550							
0	560							
0	570							
1	580							100

JOB PERFORMANCE REPORT

State of: **Idaho**

Name: **River and Stream Investigations**

Project No.: **F-73-R-16**

Title: **Angler Exploitation of Rapid River Bull Trout and Incidental Harvest of Bull Trout by Steelhead Trout Anglers**

Subproject No.: **II**

Job : **2B**

Study No.: **IV**

Period covered: **April 1. 1993 to March 31. 1994**

ABSTRACT

I estimated 1993 angler exploitation of the Rapid River bull trout *Salvelinus confluentes* stock using radio and Floy tagged fish which survived spawning. Exploitation was 16.7% for radio tagged and 17.5% for Floy tagged fish during 1993-94. The majority of the 1993 harvest occurred in the Little Salmon River following spawning.

I utilized a postal survey of steelhead trout *Oncorhynchus mykiss* permit holders to evaluate incidental catch of bull trout in steelhead trout fisheries. Few anglers targeting steelhead trout caught bull trout. Only 5.7% and 12.3% of the steelhead trout permit holders caught bull trout during fall and spring seasons, respectively. Those steelhead trout permit holders who did catch bull trout indicated they were fishing specifically for bull trout. Anglers voluntarily released 82.5% and 88.2% of the bull trout captured during fall and spring, respectively. Most bull trout captured were less than 400 mm (71%) and only 4% exceeded 500 mm, Idaho's trophy goal. The Idaho Department of Fish and Game Commission closed bull trout to harvest beginning January 1, 1994. The data reported here can be used to evaluate limited harvest in the future. I conclude harvest bag limits would have little effect on bull trout harvest by steelhead trout fishermen, but minimum size limits could be an effective tool.

Author:

Steven Elle
Senior Fishery Research Biologist

INTRODUCTION

Bull trout Salvelinus confluentus commonly inhabit cold, sterile waters and mature at 5-7 years of age (Fraley and Sheppard 1989; Goetz 1989). Bull trout are aggressive feeders and are easily caught. Often harvest of bull trout occurs before they reach sexual maturity (David Berry, Alberta Fish and Wildlife, personal communication). Thus, they are considered susceptible to overharvest by sport fishing in the northwest United States and Canada (Boag 1987; Carl 1985; Collins 1992; Curt Kraemer, Washington Department of Wildlife, personal communication). Conclusions on overharvest are generally based on limited data, however. Few estimates of exploitation (the proportion of the population harvested annually) are available, either for Idaho or elsewhere in the northwest (Cross 1985; Fraley 1985; MacDonald 1985; Carl 1985). These estimates are all based on extremely small sample sizes. Accurate estimates of exploitation are critical to evaluating sport fishing regulations. They allow the calculation of a natural mortality estimate when Z (total mortality) is known (Richer 1975). Without estimates of exploitation and natural mortality, it is not possible to predict the response of a stock to various angling regulations.

During steelhead trout Oncorhynchus mykiss fall and spring fishing seasons, bull trout populations overwinter in the main Salmon River (Bjornn and Mallet 1964; Schill et al. 1994). Incidental harvest of bull trout during the target steelhead trout fishery occurs but the magnitude and location of harvest is unknown.

The capture of bull trout leaving Rapid River following spawning (Job 1) provided the opportunity to mark adult bull trout which overwinter in steelhead fisheries. I estimated bull trout exploitation in this fishery based on tag returns. The statewide steelhead trout harvest survey database provided an opportunity to survey incidental bull trout harvest by steelhead trout fishermen and evaluate locations and numbers bull trout caught.

OBJECTIVES

Research Goal: Provide sufficient life history data to maintain and restore bull trout for trophy fishing opportunities.

1. To determine the rate of angler exploitation on Rapid River bull trout and estimate the effects on the population.

2. To determine the magnitude and spacial distribution of bull trout harvest in steelhead trout fisheries.

METHODS

Bull Trout Exploitation

During operation of the outmigrant trap on Rapid River (see Job 1) we tagged all bull trout ≥300 mm with Ploy Tags (Dell 1968). Fish were collected from the downstream trap, anesthetized with MS 222, measured to the nearest millimeter total length, and tagged with individually numbered Floy tags. Idaho Department of Fish and Game offered a $5.00 reward to anglers who returned Ploy tags. Tags were stamped with reward information on the shaft. Internal radio tags used for migration tracking and spawning mortality estimates were present in 17 fish following spawning. The radio tags each had a $25.00 reward printed on the casing in addition to the Floy tags.

Exploitation was calculated as the proportion of tags at large returned by anglers. One estimate was made based on 60 Floy tagged fish released at the Rapid River weir from September 13 through October 20. Exploitation for Floy tagged fish was estimated using angler tag returns, nonreport bias of 40% (Nichols et al. 1991), and an estimate of 10% Floy tag loss (Waldman et al. 1991; Greenland and Bryan 1971; Muoneke 1992). I calculated a second estimate of exploitation using the 17 radio tagged fish and a lower non-report correction (30%) that has been reported for similar value tags (Nichols et al. 1991).

We posted angler information signs along the Little Salmon and Salmon rivers to inform anglers about reward tagged bull trout. We asked anglers to harvest Floy and radio tagged fish only if they would normally do so. We did not advertise the higher rewards for radio tags on the information posters because we did not want anglers increasing harvest of bull trout due to the high reward. We requested anglers report date, location, and tag number with any tag return. The signs directed anglers where to report the information. We made news releases in newspapers from Lewiston to Boise, Idaho to inform fishermen of the bull trout study program and the reward tags.

Bull Trout Harvest Estimate

I conducted a post card survey to estimate the temporal and spacial catch and harvest of bull trout reported by steelhead trout anglers in Idaho. Surveys were conducted for the 1992 fall fishery (October 1 to December 31) in the Snake and Salmon rivers. A spring survey (January 1 to April 30) also included the Clearwater River fishery. Idaho Department of Fish and Game annually conducts a telephone survey of steelhead trout permit holders to estimate harvest (McArthur 1992). I used the steelhead trout survey data base to create a subsample of anglers who fished for steelhead trout during fall 1992 and spring 1993. I contacted these anglers by mail to evaluate their catch of bull trout.

An initial mailing was sent to the anglers 2 to 3 months following the end of the fall and spring steelhead trout seasons. A second mailing was sent to nonrespondents 2 to 3 weeks following the initial survey mailing. An expansion factor was determined by dividing the steelhead trout permit holders who fished for steelhead trout by the number of bull trout survey responses. For the fall 1992 sample, we had 897 responses returned from both mailings (sample size = 1507) (Table 1). I estimated an expansion factor of 14.7 to derive bull trout catch estimates from survey responses. I received 752 responses from 1,347 mailings for the spring 1993 sample. The estimated expansion factor equalled 20.37 for the spring sample period. I multiplied the results from the sample response by the appropriate expansion factors to estimate harvest by steelhead trout permit holders.

The questionnaire contained four questions to evaluate incidental catch of bull trout during steelhead trout fisheries (Appendix A). I asked anglers to report total catch (kept plus released fish) by steelhead trout management zone (Appendix B), size of bull trout caught by 200 mm length groups (200 to 600 mm), and whether anglers caught bull trout by accident (incidental catch) or on purpose (targeted catch).

RESULTS

Bull Trout Exploitation

Initially, I calculated a minimum exploitation estimate based on confirmed angler returns. During 1993-94, 2 of 16 radio tagged bull trout were reported as harvested by anglers. The minimum exploitation rate for radio tagged bull trout equalled 12.5% (95% C.L. = -4-29%) (Table 2). Anglers reported harvesting 7 of 60 (11.7%) of Floy tagged bull trout during the fall 1993 steelhead trout fishery (95% C.L.= 4-20%). A combined estimate using both tag groups (n = 77) was 11.7% (C.L. = 5-19%).

Use of non-response values from the literature elevated observed exploitation estimates. Using a 40% non-reporting bias and 10% tag loss for $5 reward Floy tags results in an estimated exploitation rate of 17.5%. For radio tags non-reporting bias of 30%, the exploitation estimate equals 16.7%.

A large percentage (89%) of the reported harvest occurred in the Little Salmon River shortly after the fish exited Rapid River (Appendix C). One angler caught four tagged bull trout (keeping one) within 24 h of capture and tagging at the downstream trap.

Bull Trout Harvest Estimate

An estimated 936 (12.3%) of the steelhead trout permit holders (SHP) caught bull trout during the fall 1992 steelhead trout fishery in the Snake and Salmon rivers (Table 3). Estimated catch equalled 5,497 fish. SHP harvested 11.8% of all bull trout caught during the fall fishery (646 fish). Twenty-seven percent of the reported catch exceeded 400 mm (16 in) and 3.9% exceeded 500 mm (Table 3).

Table 1. Subsample of steelhead trout tag holders used to estimate bull trout catch in fall (October 1 to December 31) 1992 and spring (January 1 to April 30) 1993 steelhead trout fisheries.

Season	SH permit Holders[a]	BT survey mailing	Not deliverable	BT sample	Angler responses	Expansion factor[b]
Fall 1992[c]	22,780	1,507	61	1,446	897 (62%)	14.70
Spring 1993[d]	15,320	1,347	82	1,265	752	20.37

[a] Permit holders who fished. 52.6% of spring tag holders.
[b] Expansion factor provides expansion from sample to population and accounts for nonresponse of bull trout sample.
[c] Fall survey only covered Snake and Salmon rivers, 57.9% of anglers.
[d] Spring survey covered Snake, Salmon, and Clearwater rivers.

J2B_T1

Table 2. Confirmed angler returns of bull trout >300 mm in the Little Salmon and Salmon rivers (September 20 through December 31). Fish collected and marked during emigration from Rapid River following spawning.

Type of tag	Number of tags released	Tag Returns[a]	Confirmed return rate (95% C.L.)
Radio	16[b]	2	12.5% (-4 to 29%)
Floy	60	7	11.7% (4 to 20%)
Total	76	9	11.7% (5 to 19%)

[a] Returned by anglers for rewards.
[b] 17 Radio-tagged fish survived past spawning - one tag confirmed out of fish in Little Salmon River.

J2B_T2

Table 3. Estimated number of anglers catching bull trout, numbers caught, and size distribution of the catch for Salmon River and Snake River steelhead trout anglers during fall (October 1 to December 31) 1992.

		Estimate	
Number that caught bull trout			
	yes	1,617	(12.3)
	no	11,569	(87.7)
Estimated bull trout catch			
	kept	646	(11.8)
	released	4,851	(88.2)
Estimated bull trout caught by size class			
	200-300 mm	1,544	
	300-400 mm	2,308	
	400-500 mm	1,205	
	500-600 mm	162	
	over 600 mm	44	

J28_T3

During the spring 1993 steelhead trout fishery, an estimated 876 (5.7%) of the SHP caught bull trout (Table 4). The spring questionnaire included Clearwater River fishermen along with Snake River and Salmon River anglers. Estimated bull trout catch equalled 4,196 fish with 733 (17.5%) harvested. Fewer spring anglers caught bull trout compared to the fall fishery, but a higher percentage of the bull trout were harvested. Similar to the fall fishery, 33% of the reported catch exceeded 400 mm and 4.4% of the fish exceeded 500 mm.

Bull trout catch (total numbers caught) by steelhead trout fishermen is concentrated in the Salmon River with a large percentage occurring in management zones 13, 14, and 15 (Table 5). The areas below the Little Salmon River (zones 10 and 11) also have a concentration of bull trout catch. Relatively few fish are caught in the Snake and Clearwater rivers compared to the Salmon River (Table 5). Catch in the spring fishery declined compared to the fall fishery with most of the reduction occurring in zones 13, 14, and 15.

Based on data from the survey for both fall 1992 and spring 1993, some SHP targeted bull trout. Nearly all of these anglers who targeted bull trout caught at least one (Table 6). Conversely, few anglers who specifically fished for steelhead trout caught bull trout. There was a highly significant difference in success rates between SPH fishing specifically for steelhead trout and those targeting bull trout ($P < 0.001$).

DISCUSSION

This study used reward tags voluntarily returned by anglers as an estimate of angling exploitation. Sportsmen's return of animal tags has been documented at 30-40% for nonreward tags and bands (Henny and Burnham 1976; Folmar et al. 1980; Conroy and Blandin 1984; Nichols et al. 1991). Cash rewards can reduce the nonresponse bias. Nichols et al. (1991) found a 30% nonresponse return of $25.00 and 40-50% nonresponse of $5-$10 reward duck bands. Zale and Bain (1994) documented angler nonresponse of 35% for returning simulated reward fish tags. Nonresponse could be influenced by many factors. Anglers may keep tags as mementos or good luck pieces (Butler 1962; Rawstron 1971). Anglers may have believed they had done something wrong by killing a radio tagged trout. As of January 1, 1994, bull trout fishing was closed to harvest. Illegal harvest may have inhibited tag returns for fish caught after January 1.

Based only on angler tag returns, I calculated a minimum exploitation rate of 11.7% and 12.5% for Floy and radio tagged fish, respectively. Using the nonresponse values from the literature, I estimate actual exploitation at 17.5% and 16.7% for Floy and radio tagged fish, respectively. The values used for nonresponse by anglers to turn in fish tags was 30% to 40% for tag values of $5 and $25, respectively (Nichols et al. 1991; Zale and Bain 1994).

We assumed Floy tag loss from study fish was 10%. Studies have documented losses of Floy tags between 11% and 42% (Waldman et al. 1991; Greenland and Bryan 1971; Muoneke 1992; Edner and Copes 1982). Edner and Copes (1982) indicated tag loss increased through 2-3 years after application

Table 4. Estimated number of anglers catching bull trout, numbers caught and size distribution of the catch for Salmon, Snake, and Clearwater rivers steelhead trout anglers during spring (January 1 to April 30) 1993.

	Estimate	
Number that caught bull trout		
yes	876	(5.7)
no	14,442	(94.3)
Estimated bull trout catch		
kept	733	(17.5)
released	3,463	(82.5)
Estimated bull trout caught per size class		
200-300 mm	1,752	
300-400 mm	1,039	
400-500 mm	1,181	
500-600 mm	163	
over 600 mm	20	

J2B_T4

Table 5. Reported numbers of bull trout kept and released by steelhead trout management zone for steelhead trout permit holders during fall (October 1 to December 31) 1992 and spring (January 1 to April 31) 1993.

Zone	Location	Fall 1992[a] Number anglers	Fall 1992[a] Kept	Fall 1992[a] Released	Spring 1993[b] Number anglers	Spring 1993[b] Kept	Spring 1993[b] Released
	Snake River						
1	Below Salmon River	3	1	2			
2	Salmon River to Hells Canyon Dam	1	0	1	1	2	0
Totals		4	1	3	1	2	0
	Clearwater River						
3	Below Orofino Bridge				2	1	2
4	Above Orofino Bridge	1	0	1			
5	North Fork Clearwater River to Dam				2	0	18
7	South Fork Clearwater River to Dam				1	0	1
Totals		1	0	1	5	1	21
	Salmon River						
10	Below Whitebird Creek	4	3	5	2	10	14
11	Whitebird Creek to Little Salmon River	11	5	17	3	0	8
12	Little Salmon River to Vinegar Creek	4	1	5			
13	Vinegar Creek to South Fork Salmon River	7	6	21	2	1	3
14	South Fork to Middle Fork Salmon River	32	11	10	6	0	16
15	Middle Fork to North Fork Salmon River	45	6	14	19	4	85
16	North Fork Salmon River to Lemhi River	2	0	4			
17	Lemhi River to Pahsimeroi River	3	0	6	4	9	4
18	Pahsimeroi River to East Fork Salmon	5	7	13	4	3	5
19	Above East Fork Salmon River				[illegible]	[illegible]	[illegible]
20	Little Salmon River	1	0	2	3	5	14
Totals		113	39	32 2	44	33	14 9

[a] Survey for Snake and Salmon rivers only.
[b] Survey for Snake, Salmon, and Clearwater rivers.

J2B_T5

Table 6. Percentage of survey steelhead trout permit holders who caught bull trout stratified by the species of fish they were trying to catch (targeting); BT = bull trout; SH = steelhead-trout; and Other = rainbow trout, cutthroat trout, and mountain whitefish.

Season	Caught BT	Fish species targeted SH	BT	Other	Chi-square probability
Fall n = 897		87.6%	11.6%	0.8%	
	No	100%	1%	0%	P < 0.001[1]
	Yes	0%	99%	100%	
Spring n = 748		94%	5%	0.5%	
	No	100%	0%	0%	P < 0.001[1]
	Yes	0%	90.7%	9.3%	

[1] Highly significant

J2B_T6

for lake trout _Salvelinus namaycush_. We used a more conservative rate due to the short period between tagging and the majority of tag returns in fall 1993.

The estimated exploitation rates were similar for both radio and Floy tagged fish during 1993. After correcting for nonresponse bias and Floy tag loss, the two estimates were still similar. For the period of September 20 to December 1993 exploitation on Rapid River bull trout was probably in the range of 15-20%. During 1992, Schill et al. (1994) observed an angler exploitation of 15% for radio tagged fish in the Salmon River. The sample size was only seven fish and no rewards were advertised, but the rate was similar to ours.

In this study, I only looked at the fall portion of angler exploitation. If we assume harvest during the spring steelhead trout fishery and the upstream migration is similar to the fall fishery period, it is possible angler exploitation historically approached 30-40% for Rapid River bull trout. An exploitation rate of 15% may not have limited this bull trout population. If exploitation did approach speculated rates of 30-40%, however, we may see the stock respond with increased numbers and size of fish in the spawning run with restricted harvest.

Few studies have been designed specifically to evaluate bull trout exploitation, but several authors have made indirect approximations. Fraley (1985) used creel census and spawner escapements to approximate exploitation at 25% for the Flathead River in 1981. Cross (1985) used a sample size of 24 marked bull trout to derive an estimated exploitation of 30% for the lower Flathead River in 1984-85. Based on voluntary angler returns of Floy tagged fish with no rewards, Allan (1980) estimated angler exploitation for fluvial bull trout at 19% in the Clearwater River of Alberta, Canada during 1978.

Radio tracking results indicated most bull trout resided in the Little Salmon River for 1 to 6 weeks following spawning during 1993. A large portion of the harvest occurred during this period. Several anglers reported catching multiple bull trout which were concentrated in the deeper pools. During 1992, Schill et al. (1994) observed bull trout moved rapidly through the Little Salmon River into the Salmon River. The difference may be due to higher flows and cooler temperatures during 1993. Drought conditions resulted in historic low flows in most of Idaho during 1992. Conditions during 1993 may resemble more "normal" years, and high harvest rates in the Little Salmon River should probably not be considered abnormal.

The bull trout harvest survey included the Snake, Salmon, and Clearwater rivers. Given the large geographical area covered, relatively few bull trout (646 during fall and 733 during spring) are harvested in the steelhead trout fishery (Table 5). We did not attempt to estimate harvest by zone because of small sample sizes for each zone. Such harvest could be important to local bull trout populations, however. For example, the approximate harvest estimate during fall 1992 and spring 1993 for zone 18 (the Salmon River from Pahsimeroi River to East Fork Salmon River) equals 163 bull trout. Again, no confidence limits are possible because of limited sample size. If accurate, however, this represents a major portion of the spawning escapement (approximately 100 fish) for the East Fork Salmon River, one of the major recruitment areas for this section of the Salmon River (Schill 1992). Recruitment from other Salmon River tributaries upstream from the East Fork Salmon River could supplement the number of bull trout in zone 18 and offset harvest impacts to the East Fork Salmon River stock.

In the postal surveys we had 62% and 60% return of the deliverable questionnaires for the fall 1992 and spring 1993 seasons, respectively. I assumed the respondents represented those who did not respond, and did not test for nonresponse or recall bias. Babbie (1990) indicates a response rate of 60% is considered good for analysis and reporting. The bull trout survey sample was taken from steelhead trout fishermen who indicated they had fished during the steelhead trout season in question. Therefore, we do not believe a response bias exists based on nonrespondents not fishing. The potential still exists that nonrespondents could be more or less successful in catching bull trout than the respondents.

My estimates of bull trout harvest (646 fall 1992 and 733 spring 1993) should not be used as total estimates of bull trout harvest on these rivers. The survey only included steelhead trout permit holders. Some river sections are open year around to trout fishing. Therefore, this is a minimum estimate of historical harvest prior to catch and release regulations.

The fall 1993 steelhead trout fishery represents an opportunity to collect additional baseline data on harvest of bull trout prior to catch-and-release regulations. These surveys are relatively inexpensive. The information represents an opportunity to expand our knowledge of possible angling impacts on bull trout, a species petitioned for listing under Endangered Species Act.

The Idaho Department of Fish and Game Commission closed bull trout to harvest statewide effective January 1, 1994. If stocks rebound and this harvest closure is ever changed, Idaho Department of Fish and Game will need to know what affects bag or size limits would have on bull trout harvest. Bull trout caught incidental to steelhead trout fisheries are primarily released (88.2% in fall and 82.5% in spring). Of the anglers who reported keeping bull trout, 28% kept three or more fish for the entire census season. A bag limit would, therefore, provide limited harvest reduction on bull trout harvest during steelhead trout fisheries. Assuming anglers accurately reported fish lengths, minimum size restrictions could provide management options for future bull trout harvest (tables 3 and 4). A 400 mm (16 in) or a 500 mm (20 in) minimum size limit would require the release of about 71% and 96%, respectively, of all bull trout caught by steelhead permit holders. During 1993 only 6.7% of the upstream migrating bull trout captured at Rapid River exceeded 500 mm. Given present population size structures, I conclude a 500 mm size limit statewide would protect a higher percentage of bull trout from harvest within fluvial and resident populations.

With restricted harvest regulation changes in January, Idaho joins Montana, Oregon, Washington, and Alberta, Canada in virtually eliminating bull trout harvest. Other agencies have often used bull trout spawning surveys to indirectly monitor population response to regulations (Ratliff et al. 1994; Fraley and Sheppard 1989; Curt Kraemer, Washington Department of Wildlife, personal communication). Idaho Department of Fish and Game has the benefit of several permanent salmon trapping facilities where we also capture bull trout during upstream migrations. These facilities provide more accurate data on bull trout population trends compared to spawning surveys, especially for populations with limited numbers of adults. The collection of detailed bull trout population data should be a high priority for salmon trapping stations. Numbers, size, and timing data for bull trout captured at weirs will allow the Idaho Department of Fish and Game to monitor population response to restricted harvest regulations. Scale samples should also be taken from all bull trout collected at these weirs (see Job 2A).

Bull trout catch data from the harvest survey can indirectly indicate areas of bull trout overwintering. Areas of high bull trout catch include zones 10 and 11 (mouth Salmon River to Little Salmon River), zones 14 and 15 (Vinegar Creek to North Fork Salmon River) and zone 18 (Pahsimeroi River to East Fork Salmon River). I believe these areas correspond to major populations in Little Salmon River and Slate Creek; South, Middle and North forks Salmon River; and Yankee Fork and East Fork Salmon River, respectively. Few fish were caught in the Snake and Clearwater rivers, indicating fewer bull trout in these areas. An obvious weakness of these observations is that the data may simply reflect where steelhead trout fishermen fish. Steelhead trout angler distribution is affected by distribution of steelhead trout and angler access to roadless river sections, but I believe the data do help identify important overwintering areas.

RECOMMENDATIONS

1. The Idaho Department of Fish and Game Commission closed bull trout harvest statewide effective January 1, 1994.

2. Include bull trout data collection for spawning number and size at all salmon trapping facilities. This data will provide an ongoing evaluation of the new harvest restrictions.

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A P P E N D I C E S

Appendix A. Introduction and questionnaire used to assess bull trout catch statistics for steelhead trout fishermen during fall 1992 and spring 1993.

Dear Angler:

The Idaho Department of Fish and Game is conducting a survey to estimate the harvest of bull trout (Dolly Varden). In reviewing the status of bull trout populations in Idaho, we have found little information on angler harvest in our large rivers. We need this information to manage Idaho's native bull trout populations.

Your name was selected from a list of steelhead tag holders as part of a sample group to help estimate the harvest of bull trout during the fall 1992 steelhead season (September 1 through December 31, 1992). Your response to the questionnaire is important to help us estimate the number of bull trout caught from each river section. Even if you did not catch any bull trout, your response is still important to the survey results. Please help us by taking a minute to fill in the enclosed post card. To assist you in filling out the survey, a description of river sections is located on the reverse side of this letter.

Thank you for taking the time to respond to this survey. Your answers will increase our knowledge and help us to better manage your fishery resources. If any questions should arise regarding this survey, please contact Tom McArthur at the above address or call (208) 334-3791.

BULL TROUT QUESTIONS FOR STEELHEAD POSTAL SURVEY

1. Did you catch any bull trout during the spring 1993 steelhead season?

   Yes_______ No______

2. If you caught bull trout:

Number Kept	Number Released	Steelhead Section
______	______	______
______	______	______
______	______	______
______	______	______

3. Please list the number (by size) of bull trout you caught.
   08-12 inches___________12-16 inches____________
   16-20 inches____________20-24 inches____________
   larger than 24 inches________

4. If you caught bull trout, were you specifically (please check one):
   fishing for steelhead ___________________________
   fishing for bull trout __________________________
   fishing for other species _______________________

Please fill in and mail. Thank you.

J2B_AA

Appendix B. Steelhead trout management zones for Snake, Clearwater, and Salmon rivers.

DESCRIPTION OF RIVER SECTIONS

1. Snake River, below Salmon River: Asotin, Heller Bar, Grande Ronde, Lime Point, Captain John Creek

2. Snake River, above Salmon River to Hells Canyon Dam: Imnaha, Pittsburg Landing, Doug Bar

3. Clearwater River, below Orofino Bridge: Lewiston, Potlatch Cree, Hog Island, Lapwai Creek, Myrtle Beach, Cherry Lane, Lenore, Peck, McGill Hole, Pink House, Spalding Park, Slaughterhouse, Cat Hole, Tepee Hole, KOA, Bevenlins

4. Clearwater River, above Orofino Bridge: Greer, Fish Hatchery Hole, Kamiah, Kooskia, Five-Mile, Six-Mile, Miller Hole, Sawmill

5. North Fork Clearwater River from mouth to Dworshak Dam, Ahsahka

6. Middle Fork Clearwater River: Clearwater to Clear Creek

7. South Fork Clearwater River: Mt. Idaho Bridge, Miles Post 21

10. Salmon River, below Whitebird Creek: Cottonwood Creek, Graves Creek, Deep Creek, Hammer Creek, Divide Creek, Rice Creek, Pine Creek, Snow Hole, Slide Hole, Deer Creek Bridge

11. Salmon River, Whitebird Creek to Little Salmon: Whitebird Creek, Silver Bridge on Time Zone, Blackhawk Bar, Lucille, Slate Creek, Skookumchuck, Race, Fiddle, John Day Cree, Chair Creek, Riggins Boat Ramp, Riggins

12. Salmon River, Little Salmon to Vinegar Creek: Wind River Vinegar Creek, Luke and French Creek, Spring Bar, Riggins, Hot Springs, Allison Creek, Shorts Bar, Partridge Creek

13. Salmon River, Vinegar Creek to South Fork: Sheep Ranch, Bull Creek, Warren Creek, Mann's Creek, South Fork Hole

14. Salmon River, South Fork to Middle Fork: Mackay Bar, China Bar, Sabe Creek, Whitewater Ranch, Corn Creek, Chamberlain Creek, Buckskin Bills, Five-mile Creek, Bargamin Creek, (Salmon Falls), Long Tam Bridge, Big Mallard Creek, Little Mallard Creek, Bear Creek Hole, Smith Gulch

15. Salmon River, Middle Fork to North Fork: Owl, Pine, Spring Creek, Indian, Dump, Panther Creek, Deadwater, Shoup, Colson Creek, Rams Head Lodge, Dutch Oven, Cove Creek, Newland Ranch, Trapper Gulch, Ebenizier Flats

16. Salmon River, North Fork to Lehhi River: Ramshorn, Salmon, Carmen, Lemmi, Fourth of July Creek, Kriley, Red Bluff

17. Salmon River, Lemmi River to Pahsimeroi River: Ellis Down to Lehmi, Pahsimeroi, Dug Out, Shoup Bridge, Williams Lake, Twelvemile Creek, Iron Creek, Hot Creek, Cronks Canyon, Boat Hole, Sevenmile Creek, Elk Bend, Midway

18. Salmon River, Pahsimeroi River to East Fork: Challis, Warm Springs Creek, Bayhorse, Morgan Creek, Chivers Access, Highway 93 Bridge

19. Salmon River, above the East Fork: Basin Creek Down, Sunbeam Dam, Clayton, Robinson Bar, Yankee Fork, Thompson Creek, Squaw Creek, Stanley, Valley Creek, Redfish Lake Creek, Rough Creek, Holman Creek, Deadmans Rock, Ranger Hole, Torreys

20. Little Salmon River: Rapid River, Pollock, Stinky Hot Springs, Boulder Creek

Appendix C. Angler tag returns of bull trout during fall 1993.

Tag type	Tag number	Location captured	Date captured	Known angler harvest yes	no
Radio	150.385	Little Salmon River	unknown	x	
	150.375	Little Salmon River	10/08	x	
	150.422	Little Salmon River	03/06	[1]	
	150.324	Salmon River	03/08-03/31	[2]	
	150.355	Unknown	unknown	[3]	
	150.645	Little Salmon River	unknown	[3]	
	150.445	Little Salmon River	09/28		x
Ploy	B 1866	Little Salmon River	10/22	x	
	A 730	Little Salmon River	unknown	x	
	B 1873	Little Salmon River	09/22		x
	B 1868	Little Salmon River	09/22	x	
	B 1869	Salmon River	09/27	x	
	B 1827	Salmon River	10/09	x	
	B 1838	Little Salmon River	10/14	x	
	A 728	Little Salmon River	10/14	x	

[1] Angler said he found tag on a gravel bar. Does not agree with prior observations. Possible illegal harvest.
[2] Fish alive and moving on March 8. Disappeared during intense ateelhead fishery. Possible illegal harvest.
[3] Radio signals disappeared shortly after fish exited Rapid River during period other bull trout harvest occurred.

Submitted by:

Steven Elle
Senior Fishery Research Biologist
Idaho Department of Fish and Game

Russ Thurow
Research Scientist
USFS Intermountain Research Station

Tony Lamansky
Fishery Technician
Idaho Department of Fish and Game

Approved by:

IDAHO DEPARTMENT OF FISH AND GAME

Steven M. Huffaker, Chief
Bureau of Fisheries

Virgil K. Moore
Fisheries Research Manager

SIGNPAGE